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THE ELECTRICIAN:

A WEEKLY JOURNAL OF

THEORETICAL AND APPLIED ELECTRICITY AND CHEMICAL PHYSICS.

No. 1.—Vol. X. SATURDAY, NOVEMBER 18, 1882. Price 4d.

SLIP

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended November 10 were £3,626.

Electric Light for War Purposes.—Two electric lights have been erected at the entrance of the Gulf of Spezzia in Italy to illuminate it in time of war.

The Telephone in Mexico.—It is stated that before long a telephone line will unite Vera Cruz and Mexico. The distance between these towns is 372 kilometers.

Alderney.—The cable between Guernsey and Alderney is interrupted. All telegrams, therefore, for the last-named place have to be forwarded by post from Guernsey.

Eastern Extension Telegraph Company.—The traffic receipts of this company for the month of October, 1882, amounted to £29,925, and to £31,164 for the corresponding period of 1881.

Direct Spanish Telegraph Company.—The estimated traffic receipts of this company for the month of October, 1882, amounted to £2,079, against £2,063 in the corresponding period of last year.

Notice.—Owing to the pressure on our space we are compelled to leave over our report on the Munich Exhibition, an article by M. Cabanellas on M. Deprez's experiments at Munich, and other matter.

The Royal Society.—At the anniversary meeting of this society, on the 30th instant, Mr. William Spottiswoode will be proposed for election as president again, and Professor W. Grylls Adams as a member of council.

The Telephone in Nottingham.—The number of messages transmitted through the National Telephone Company's Exchange at Nottingham for the week ending November 2, 1882, was 4,900, being 700 increase on the previous week.

Crystal Palace Exhibition.—The amount subscribed by the various gas companies towards the expenses of the special committee of the gas institute appointed to organise the gas exhibits at this exhibition now reaches £5,458 12s.

Electric Light in Cleveland.—The Ohio Electric Light and Power Company of Cleveland, U.S.A., which employs the Sherman lamp, is proposing to light certain streets by erecting arches of gas pipe from kerb to kerb, from which the lamp is suspended.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 10th November, 1882, were £2,327, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Edison Lamps on Board Ship.—Two steamers of the Union line are to be fitted with Edison lamps. The motors in these instances will be Brotherhood three-cylinder engines. Lengthened trials are being carried out with these engines as motors for Edison machines.

Electric Light for Ripon (Yorks.).—The town council of Ripon have resolved to oppose the applications of companies for leave to supply electricity, and have also decided not to apply for a provisional order to supply it themselves. The gasworks are owned by the town council.

The Lighting of the Royal Palaces.—We hear that the work connected with the lighting of Windsor Castle and the Royal palaces has been placed in the hands of Mr. W. H. Massey, of Twyford, Berks, who some time ago resigned the post of general manager of the Maxim-Weston Company.

Great Northern Telegraph Company.—The traffic receipts of this company for October, 1882, amounted to £21,440; for the period from 1st January to 31st October, 1882, they were £203,280, for the corresponding months of 1881 £201,359, and for the same period of 1880 £198,991.

The Bell Telephone Patent.—An American paper says:—"The Bell patent would, it is considered by those competent to form an opinion, be cheap at 10,000,000 dols. The consolidated telephone interests of the United States are estimated at from 100,000,000 dols. to 150,000,000 dols."

New Atlantic Cable.—The *New York Herald* of recent date announces the arrival of Mr. Bennett in that city with the special object of completing arrangements with Mr. Garrett, of the Baltimore and Ohio Railroad, for laying the new cable. Mr. Bennett sailed again for Europe a few days after.

Society of Telegraph Engineers and of Electricians.—The next meeting will take place on Thursday, the 23rd inst., at 8 p.m., when the following Paper will be read: "Notes on the Telegraphs used during the Operations of the Expeditionary Force in Egypt," by Lieut.-Colonel C. E. Webber, R.E., president.

The Maxim-Weston Electric Company.—We learn that Mr. Hugh Watt, merchant, of London and Liverpool, has joined the board of this company as managing director. Much useful work is now being done by the company, thanks to the energy of its late manager, Mr. Massey. We hope

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that this happy state of affairs will be maintained under the new management.

THE TELEPHONE IN ITALY.—The number of subscribers to the various exchanges of the Société Italienne des Téléphones was as follows on the 15th October last:—In Turin 383, Milan 398, Genoa 383, Florence 281, Venice 114, Bologna 166, Livorno 124, Messina 69, Rome 530, Naples 351, Palermo 150, Catania 54, making a total of 3,003.

THE TELEPHONE IN FRANCE.—The Minister of Posts and Telegraphs has decided to erect telephone lines in the following towns:—Roubaix, Tourcoing, Rheims, St. Quentin, St. Etienne, Fourmies, Cannes, and Nice. He has also authorised the Société Générale des Téléphones of Paris to open exchanges in Alger, Oran, and St. Pierre-les-Calais.

A RAID ON TELEPHONES IN PARIS.—The Société Générale des Téléphones has just made a raid in Paris on all persons making and selling telephones, which they assert are infringements of the Edison patent, and has issued a notice warning the public against making, selling, or retaining possession of such telephones unless they have the company's trade mark on them.

NEW SECONDARY BATTERY.—A Belgian contemporary announces some improvements on the Faure battery effected by Messrs. Tamine, a civil engineer, and Arnould, chief engineer of mines at Mons, in that country. The improvements consist in forming the plates of metal wire wound in a spiral form, and placed in sulphate of copper. The felt of Faure is replaced by very thin discs of porous earthenware.

ELECTRIC LIGHTING OF ROPE AND TWINE MILLS.—The extensive mills belonging to Mr. A. Balstone, of Poole, Dorset, were lighted by electricity on Thursday last. Pilsen arc lamps of 2,000 c.-p. were made use of, and notwithstanding the immense amount of machinery in each room we are given to understand that the lighting proved exceedingly satisfactory. The installation was effected by Mr. R. Bayley, of Poole.

ELECTRIC LIGHTING IN LONDON.—The Bermondsey Vestry do not seem to be much impressed with the recent conference of the local authorities of South London on the subject of electric lighting. A member, who acted as the vestry's delegate at the conference, described his impression of the proceedings as "a jumble of figures which came from a man interested in gas shares." The St. Pancras Vestry will apply for a provisional order.

A MICROMETRICAL MACHINE.—*La Nature* for the 11th November describes a micrometrical machine, which has been constructed by M. Perreaux, and which is capable of measuring one 1,500th part of a millimeter. The machine is so delicate that it is impossible to use it excepting during certain hours of the night, when all vehicular traffic has ceased. Some idea of the minute measuring powers of this machine may be gathered when we say that a millimeter is equal to about $\frac{1}{25}$th of our inch.

ELECTRIC LIGHTS IN MILLS.—Electric lights are now extensively employed in the mills at Holyoke, Mass. The Weston Company have 45 lamps in the Hadley thread mill, the Edison Company 95 lamps in the Little Hampden mill, and the Appleton-street mill, owned, like the preceding, by the Merrick Thread Company, is to be wired for 1,000 Edison lamps. The Whiting paper mill has 100 electric lamps, and the Germania mill has used them since August.—*Sanitary Engineer* (New York).

THE VOLTAIC ARC BETWEEN PLATINUM ELECTRODES.—Gassiot found that, even when a combination of 320 Daniell cells was employed, no spark could be obtained between two platinum surfaces connected with the two poles of the battery, although the two surfaces were brought within $\frac{1}{3000}$ of an inch of each other. If, however, the transfer of some material particles be effected between the two surfaces, either by a momentary contact or even by the discharge of a Leyden jar across the interval, the current may be established and the arc maintained with a small number of cells.

THE EDISON COMPANY AND THE CITY AND GUILDS INSTITUTE.—We understand that this company has entered into a contract with the City and Guilds Institute to make an installation with Edison machines and lamps. The arrangements will be carried out under the direction of Professor Ayrton, F.R.S. The conditions are, we believe, especially stringent, so that the success of this installation will be a far greater proof to the public mind than that of an ordinary installation carried out by the engineers of the company. We hope to give full details of this work in an early issue.

CHINA TELEGRAPHS.—In consequence of the dissatisfaction amongst the mercantile community of China, arising from the frequent interruption of the cable between Hong Kong and Shanghai, in which the Eastern Extension Telegraph Company are equally interested with the Great Northern Company, the Eastern Extension Company are anxious to afford the public the benefit of as good a service as exists over the rest of their system, and they have, we believe, determined to at once take steps to arrange for the construction of a new line, either by land or sea, between those important Treaty Ports.—*London and China Express.*

SWAN'S LAMPS IN A FACTORY.—Messrs. Guinness, Son, and Co., of Dublin, have had the looms in their new woollen factory lighted up with Swan's incandescent lights, the current being supplied by a Crompton-Bürgin machine. The result has been so satisfactory that this firm have entrusted an order to Mr. J. H. Greenhill, of Belfast, who supplied the above plant, for the introduction of Swan lights into their extensive offices in connection with the breweries. We understand Mr. Greenhill has obtained the concession of manufacturing the Crompton-Bürgin machines in Ireland, being the first dynamos made in that country.

WIRE FENCING IN THUNDERSTORMS.—During the thunderstorm of Wednesday week five sheep were killed on the farm of Cotland, Tinwald parish, in Scotland. In one field there was a wire fence for a distance of 300 yards. The current had travelled along this, breaking the wooden posts at various distances, and at the end of the fence two sheep were struck and killed. In an adjoining field, separated from the other by a farm road, the fence was a stone wall, with a single wire on the top. This wire was broken, and touched the ground about forty yards from the road. A number of sheep were crouching near the broken wire, and three of them were killed.

THE EDISON SYSTEM IN STOCKHOLM.—The Edison system has been successfully in operation in Stockholm since the 24th of May last. The different points lighted by the system have been visited by the Royal Princes, members of Parliament, the Municipal Council, and various dignitaries of Stockholm and other cities. The café in front of the Royal palace is one of the places thus lighted, and during the summer months its freedom from undue heat has been much remarked upon by the persons visiting it. The lamps and machines were erected by Messrs. Dreyfel and Co., of Stockholm, for the Edison Foreign Electric Company, by whom the plant was supplied.

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India Rubber and Wire Wanted.—The Great Southern and Western Railway Company (Ireland) invite tenders for the supply, amongst other things, of india rubber and wire for one year. Forms of tender can be obtained on payment of 6d. each from the company's storekeeper at the General Stores, Inchicore, Dublin. Tenders are to be sent to Mr. F. B. Ormsby, secretary, Kingsbridge Terminus, Dublin, by 10 a.m. on the 27th November. The Midland Great Western Railway Company (Ireland) are also inviting tenders for the same goods. Forms of tender can be had at the General Stores, Broadstone Station, Dublin, on payment of 6d. each. Tenders to be sent to the chairman, at the above station, by the 5th December.

Fire Alarms in New York.—Much comment has been caused by the fact that, although there was a special fire-alarm signal-box in the Park Theatre, New York, which was recently destroyed by fire, no alarm was received from it at the central station, and much valuable time was lost until an alarm was given from somewhere else, more than a block away. According to a New York paper, a workman ran to the box in the theatre, broke the glass case, and endeavoured to give the alarm, but he was probably so excited that he failed to push in the button to send the alarm, and now seeks to cast the blame upon the signal-box or the Fire Department. The same authority says that it has been also claimed that the difficulty was caused by the underground wires being out of order.

New Cable Ship.—We announced in a recent Note that the Postmaster-General had contracted with Messrs. D. J. Dunlop and Co., Port Glasgow, to build for the service of the Post Office an iron screw steamer, specially constructed for the laying and repairing of telegraph cables. The vessel will be built from designs by Mr. Joseph H. Ritchie, Fenchurch-street, E.C. The principal particulars of the vessel are:—Length, 240ft; breadth, 33ft.; depth, 20ft.; to be propelled by a pair of engines having cylinders 30in. and 58in. diameter, with a length of stroke of 48in. To meet the requirements of the special work to be performed, the steamer will be fitted with three circular telegraph cable tanks and a double bottom for water ballast, with fittings adjusted to trim the ship as the cable is paid out.

Chutaux's Battery.—This battery is used in London by the Submarine Telegraph Company. It is composed as follows:—The carbon plate is surrounded with fragments of the same substance, and the zinc with silicious sand. A small porous jar, held at the upper part of the cell, is surmounted by an inverted bottle, containing a bichromate solution. This exciting liquid leaks through the small porous jar, moistens the mass beneath, and drains off from the lower part into a second cell underneath the first, and thence into a receiver, in the shape of a bottle. It is here caught, and can be used again once, and even twice. The carbon is vase-shaped, and surrounded by cardboard, which, under the action of the sulphuric acid, becomes pasty, but this does not appear to increase the resistance much. The E.M.F. of the cell is about 2·2 volts.

Bichromate Batteries.—Amongst other recent modifications that have been introduced in these batteries is that of Messrs. Voisin and Dronier. It consists in the use of dry or solid salts, which only need to have water added to them in the cell to render it ready for action. The salts are used in the proportion of one-fourth of the weight of the water. The constitution is, for the sulphate of potash salt: water, 80 grammes; sulphuric acid, 11·80; bichromate, 5·20; sulphate of potash, 3 grammes. When sulphate of soda is used instead of potash, the proportion of bichromate is 5·40, and of sulphate of soda 2·80 grammes. The salt is prepared as follows:—The sulphate is dissolved in the sulphuric acid by heating, and the bichromate added slowly. When cool the mass solidifies, and just before this takes place—that is, when the mass is not quite cool—it is cast into moulds.

Army Post Office Corps.—The Postmaster-General has directed that the following memorandum from Lieutenant-General Sir Garnet Wolseley, G.C.B., late Commander-in-Chief of the British forces in Egypt, shall be published for the general information of the officers of the Department:—"I have much pleasure in bringing to the notice of the Secretary of State the admirable manner in which the Post Office Corps discharged its duty in Egypt. Their discipline was excellent, and the officers, non-commissioned officers, and men carried out the important duties entrusted to them throughout the campaign in a manner which left nothing to be desired. Their services have been so valuable that I hope a similar corps may be employed on any future occasion on which it may be necessary to despatch an Expeditionary Force from this country.—(Signed) G. J. Wolseley, A.-G."

Electric Light in a Stockport Mill.—Messrs. R. M'Clure and Sons, of Travis Brook Mill, Stockport, partially lighted their weaving shed last winter with the electric light. A 16-light Brush machine, with 16 lamps, each of 2,000 candle-power, was used for the purpose, and the result was so successful that they decided to complete the lighting of their shed, and also to extend it to other portions of their mill. For this purpose they have now had erected a 40-light Brush dynamo with 40 Brush lamps, 31 of which are now in the weaving shed and the remaining nine in the engine house and other rooms. The whole of these were set running a few days since and burnt satisfactorily. The installation has been carried out by the Hammond Electric Light and Power Supply Company, Liverpool, under the superintendence of Mr. James Shaw, the district manager, and Mr. Rowley, electrician to the company for the district.

Overhead Wires in Providence (America).—The Providence *Journal* is reminded by the obstacles placed by telegraph wires in the way of setting up ladders at a recent fire, that an ordinance was passed by the City Council in July of last year providing "that all telegraph, telephone, and other wires now stretched in any street, square, lane, or alley in the first building district below the tops of buildings shall be forthwith removed from such position, and be so readjusted and relaid that the same shall hereafter be stretched and maintained above the top of said buildings." This has never been enforced, and now the Chief of the Fire Department thinks that wires should not be allowed to be placed more than 30ft. from the ground nor less than 20, and he would not allow them to be run diagonally across streets. Where it is necessary to cross streets, wire should be run directly over from poles set on the outer corners.

Overhead Telegraph Wires.—In the House of Commons on the 9th inst. Sir H. Tyler asked what progress had been made during the present year in reducing the numbers of Post Office overhead wires in the metropolitan area, and the numbers and lengths of such wires on the 1st January, 1st July, and 1st November, 1882, as well as the numbers and lengths of wires laid underground at the same periods within the same area. Mr. Fawcett said he had informed the hon. member in June last year that in the March preceding the number of underground wires within a radius of four miles was 4,388, as against 500 overhead. Since that time the underground wires had increased to 4,953, and the over-

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head wires to 515. Taking a radius of one mile from the Post Office, he found the proportion of underground to overhead wires was 1,822 miles underground, as compared with 58 miles overhead. By far the greater number of overhead wires belonged to telephone and other companies, and not to the Post Office. In one thoroughfare of 97 overhead wires only three belonged to the Post Office.

Danger from Exposed Electric Light Wire.—"A. I. C. E." writes to *The Times* of 13th inst. as follows:—"Your paragraph in *The Times* of Nov. 9 is not an instant too soon. Doubtless in England also we shall have to wait for legislation until, to use your own words, 'some dreadful accident occurs to arouse public indignation.' Meantime, public opinion, if freely expressed, may do something. It is no secret that more than one theatrical manager has in contemplation, or has already decided, to employ the electric light in the coming Christmas pantomimes or extravaganzas as a personal ornament for their hobgoblins and fairies. This can only be done by means of some form of accumulator carried by, or attached to, the individual, and whether the star light is to form an ornament for the head, or to glisten at the end of a wand, the constant danger is patent. There is no need to be an electrician to understand this. A grave responsibility will be incurred by those managers who permit it—a still graver one by those who force it on their *employés*. The life of even a super at 20s. a week ought not to be placed in jeopardy by that autocratic production of our time, the theatrical manager, even if both are willing to run the risk."

Electric Lighting in Brighton.—Mr. Magnus Volk of the Ditchling Rise Telegraph Works, Brighton, has fitted his works with Edison 8-candle lamps, and his house with the same lamps combined with Swan 16-candle lamps. The current is derived from a D^5 Siemens machine wound to give 55 volts, driven by a 2 h.-p. Otto gas engine. Mr. Volk is also engaged in fitting up Messrs. Wallis and Hack's warehouses and shop in the same town, with 20 Swan lamps of 20 candle-power, and 10 of 10 candles. These will be supplied with current by a D^7 Siemens machine, driven by a $3\frac{1}{2}$ h.-p. Otto gas engine. On the 2nd instant the King's apartments in the Royal Pavilion were successfully lighted with incandescent lamps, comprising 25 Edison 8 candle-power, 10 Swan 20 candles, and 8 ditto 10 candles. The current was supplied by a D^7 Siemens machine, driven from the large steam roller belonging to the corporation. Several shops employ the Brush system, some having the lamps inside the rooms, but the majority preferring to utilise them for the illumination of the street in front of their windows. The light given is very brilliant, and when on a visit to the town a few days since we remarked that it was much steadier than has been the case with some other lights on the same system which we have noticed.

Electric Lighting in the Country.—The Sheffield Town Council have received the draft provisional order to enable them to supply electricity in the borough which their Electric Lighting Committee have had prepared.—Weymouth Town Council held a meeting the other day to consider what should be done as to a provisional order, but, after some desultory talk, separated without arriving at a decision.—The St. Helen's (Lancs.) Town Council have decided to obtain a provisional order.—The Ilkley (Yorks.) Local Board think that the information to be obtained from the various companies and other sources as to cost of plant and the vagueness of estimates when submitted are so unsatisfactory that the question of applying for an order, or adopting the light, had better be deferred for the present.—The Airedale (Yorks.) Association of Local Boards, after listening to a paper on the Electric Lighting Act by Mr. Topham, of Tong, could not come to a conclusion, but from the tone of the discussion the general body of the members appeared to think the question somewhat unripe at present.—The Aylesbury Local Board do not think it desirable to apply for an order, nor are they inclined to support a member who proposed to set up an experimental installation in his own house, at a cost of about £3,000, to show what the electric light could do.

A Telephone System for Spain.—A correspondent of the *Bulletin de la Compagnie Internationale des Téléphones* sends the following information relating to the tenders sent in for a concession permitting the establishment of telephone lines in Spain. The tenders were as follow:—(1) Don F. Ayler, representing an English company, offered to work the lines for 20 years, fixing the amount of each subscription at 400 pesetas per annum, 50 centimes for each message sent, and offering 10 per cent. as rent to the State. (2) Don Arturo Soria offered the State 60 per cent. for a concession of six years. (3) Don Emillio Rotondo y Nicolau offered, for 15 years, 250 pesetas per annum, 25 centimes per message, and 12 per cent. for the Treasury. (4) Don Raphael Ruig y Gomez, acting manager of the Compagnie Générale de Téléphone Force et Lumière Electrique, for 15 years at 210 pesetas per year, 19 centimes per message, and $25\frac{1}{2}$ per cent. for the State. (5) Don Tomas Dalman, acting manager of the Compagnie Espagnole d'Electricité for 20 years, 240 pesetas per subscriber per year, 25 centimes per message, and 21 per cent. for the State. (6) Don Carlos A. Bertol, representing a foreign company for 20 years, 25 centimes per message, and 10 per cent. for the State. (7) Don Magin Vilasegart, for 15 years, 200 pesetas per year per subscriber, 20 centimes for each message, and 30 per cent. for the State.

A Medical Opinion of the Electric Light.—Before the electric light becomes, as it must soon become, the common illuminating agent of the period, says the *Lancet*, a determined effort should be made to devise some mode of mitigating its peculiarly unpleasant intensity. The vibratile impulse of the electric force is obviously stronger than the delicate terminal elements of the optic nerve in the retina can bear without injury. We are wont to apply the adjectives "hard" and "soft" to light, and their significance makes them peculiarly appropriate. The electric light is too hard; it needs to be softened. The waves of motion are too short, and the outstroke—so to say—joins the in-stroke at too acute an angle. This might doubtless be obviated by employing suitable material for globes and shades, but perhaps the best plan would be to break up and scatter the rays of light by reflection. If a small convex reflector were placed immediately below the light in the protecting globe, and one of larger dimensions above it, so as to secure a double reflection with ultimate divergence downwards and outwards, the effect would be to cause the "rays" of light to fall obliquely on all objects within the immediate area of illumination. This would, perhaps, obviate the need of coloured glasses, which the promoters of the electric light seem to dislike. Certainly there is a considerable sacrifice of power in the use of the opaline globe—so much, indeed, that some of the districts lighted by electricity displayed through this medium do not present any obvious superiority over gas. We throw out the suggestion for what it is worth. Something must be done, for, as it is, the electric light is "trying to the eyes," which means that it is in danger of injuring them, and already there is reason to believe mischief has been wrought by its use. For true comfort there is nothing like the light given by the old-fashioned pure wax candle.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XIX.

Modern Siemens Armature.

Return to the duplicated Siemens armature represented on p. 437, and instead of doubling its commutator and making, in fact, a double machine, let it only have a simple split ring commutator, as in Fig. 1 of the present article. The ends of the wire of the two coils, *a a* and *b b*, can be connected up as shown in Fig. 1 or Fig. 2., the consequence of which will be that the two coils are in multiple arc, and the E.M.F. in a uniform field will be $\frac{1}{2}$ (sin θ + cos θ), just as it was in the Brush mode of connection, only that now neither coil will be cut out of the circuit at its neutral position, a disadvantage which is more than compensated when many coils are employed instead of only two.

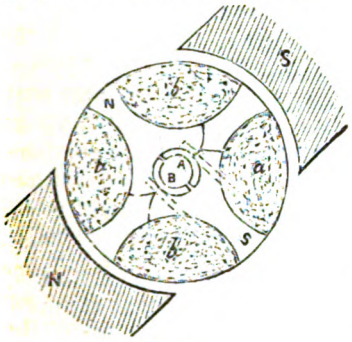

Fig. 1.

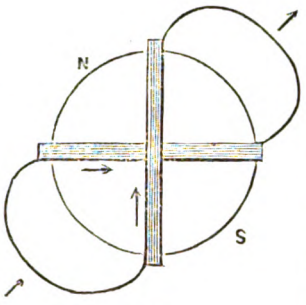

Fig. 2.

To represent the essential parts of Fig. 1 in a simple fashion, suitable for a larger number of coils, is the object of Fig 2. The two coils are shown wound over the front face of the rotating drum, and the free ends of the wire of the coils are connected together as shown, and are understood to be connected also with the two portions of the commutator. The arrows represent a direction of current, such as might be produced by rotating the drum in a magnetic field, or such as might cause the rotation of the drum if sent round it from a battery. The letters N S in Fig. 2 refer to the direction of the magnetic axis, caused by the currents flowing along the arrows.

In Fig. 1 is shown one position of the poles of the field magnet and of the springs or brushes of the commutator, but inasmuch as these are fixed while the armature and commutator rotate, all that is essential about them is that the line joining the brushes should coincide with the line joining the field magnet poles. The position shown, however, is that of maximum action.

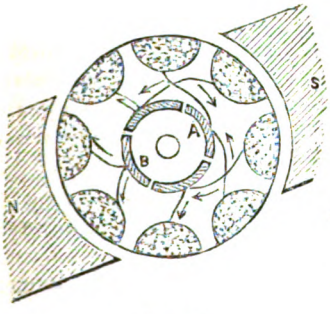

Fig. 3.

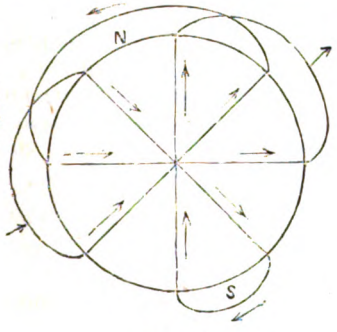

Fig. 4.

[The same is true of Fig. 2, Art. XVIII., representing the Brush mode of connection, which see and compare.]

To generate the currents indicated by the arrows in the given field we should have to rotate the armature against the hands of a watch, thereby moving the induced N pole from the fixed S toward the fixed N. Under these circumstances the brush which touches the commutator segment marked A is the positive one, from which the induced current starts into the outer circuit.

But in order to send these same currents (indicated by the arrows) through the armature from a battery, B must be made the positive pole by connecting it with the platinum end of the battery, and the rotation thereby produced will be like that of the hands of a watch.

This is in obvious agreement with Lenz's law, which says that the induced current must be in such direction as to oppose the motion.

If, instead of sending the current from a battery along the arrows, we chose to make A the positive pole for this case also, then the battery currents would oppose the *currents* produced by induction, but would tend to assist the *motion* producing them.

A little thought will make all this quite clear, but we will just recapitulate. Under the condition of things shown in Fig. 1, provided it is understood that the currents start down the *front* of the drum as indicated in Fig. 2, the following circumstances hold:—

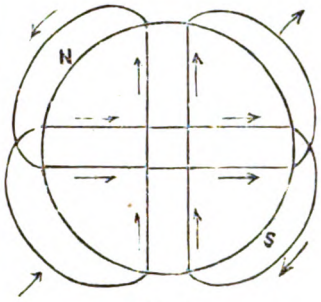

Fig. 5.

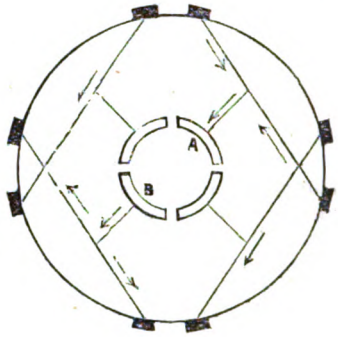

Fig. 6.

Counter-clockwise rotation will develop the arrow-shown currents, and A will be the positive brush;

The positive pole of a battery applied to A will send currents against the arrows, and will cause counter-clockwise rotation;

The positive pole of a battery must be applied to B to send the arrow-shown currents, and the rotation will then be clockwise, as is obvious by looking at the letters N N S S.

Four-coil Armature.

Now consider the drum wound with four coils, the windings being carried right across the axis, as shown in Fig. 4, where the *front* of the drum is again intended to be represented. The commutator must now be a tube split into four segments, as indicated in Fig. 3. The connections of the free ends of the coils must be made as shown in Fig. 3 or Fig. 4; the former showing more explicitly the connection with the commutator segments, which, however, is readily understood in Fig. 4.

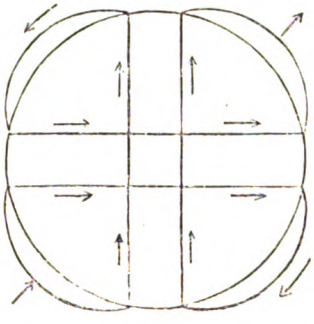

Fig. 7.

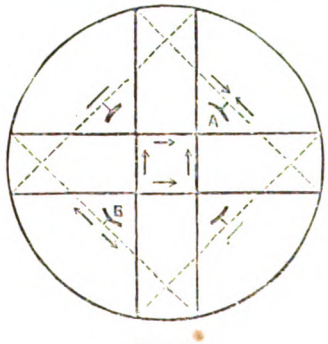

Fig. 8.

The arrows, again, show a possible system of currents, such as would be produced by a battery, of which B was the positive pole, or by a counter clockwise rotation in the magnetic field of Fig. 3, A being the positive pole for the thus induced current. Everything said about A B and N S and direction of rotation remains true; but, in addition, there are two other segments of the commutator which are idle until they are turned into the position of A B, or so near this position that the brushes rest upon them, in which case they *become* A and B.

To understand why the induced magnetism is represented in Fig. 4 in the direction N S, we must apply Ampère's rule

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to the currents, remembering that they are meant to be flowing in front of the drum, and it will be seen that N S is the *resultant* line of magnetisation for the four coils.

But the method of connection is obviously unsymmetrical and unsatisfactory, and, though no fault can be found with it electrically, a symmetrical system would be more easily recognised as correct. No symmetrical system can however be made so long as the coils are wound singly over diameters of the drum.

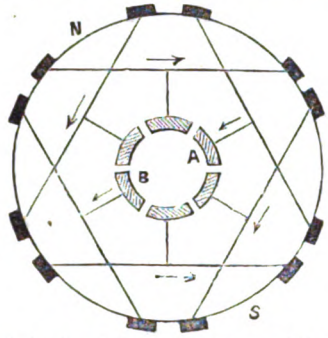

FIG. 9. NOTE.—The horizontal arrows at top and bottom of this figure should point to left, not to right.

The coils must either be wound doubly, *i.e.*, with two wires side by side—in which case, however, it will no longer be a four-coil armature but an eight, and the commutator will have to have eight segments—or the coils must be wound in parallel pairs, as indicated in Fig. 5. This not only gives symmetry, but it is also more easy to carry out in practice, as it leaves a natural space for the axle of the drum. The connections may now be made in either of the three ways repre-

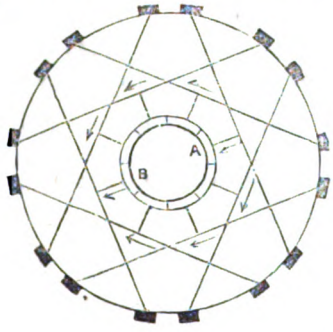

FIG. 10.

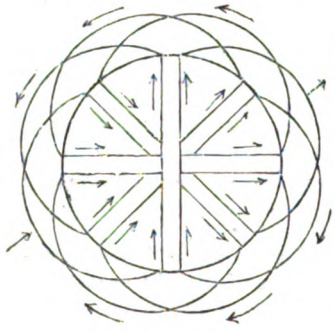

FIG. 11.

sented in Fig. 5, 7, or 8, which are, to all intents and purposes, the same. Fig. 6 is another method of representing the system Fig. 5, and it is, perhaps, the clearest and best mode of representation, all that is left to be understood being that the arrows represent the currents coming from or going to the front portions of the coils, a thing which is shown better in Fig. 5. In Fig. 8 the connections with the commutator are diagrammatically indicated, and the arrows are con-

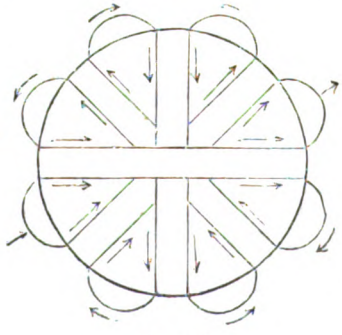

FIG. 12.

sistent in the whole series of Figs. 3 to 8. We may take Fig. 7 as the simplest type and proceed now without the slightest difficulty to the corresponding mode of connecting up a 6-coil armature with its 6-fold commutator, Fig. 9. An 8-coil armature is shown in Figs. 10 and 11, which are identical.

In all these figures A is the positive pole of the machine, if the arrows represent induced currents; moreover, it will be observed how all the arrows are flowing back from A to B past all the idle segments of the commutator. This is essential, and if any pair of these arrows were inverted it would mean that the mode of connection attempted was wrong.

Nothing is easier than to devise such an erroneous mode of connection, and for the sake of instruction an erroneous 8-coil armature is shown in Fig. 12. If a current were sent along the arrows in such an armature there would only be a feeble induced magnetisation, for one of the coils is opposing the other three, but what there was would still be along the line N S, and the machine so wound would still act, though only in a weak and wasteful way.

THE RELATIONS BETWEEN MAGNETIC FORCE AND ELECTRIC CURRENT.—I.

BY OLIVER HEAVISIDE.

Every one knows that electric currents give rise to magnetic force, and has a general notion of the nature of distribution of the force in certain practical cases, as within a galvanometer coil, for example. Further than this few go. The subject is eminently a mathematical one, and few are mathematicians. There are, however, certain higher conceptions, created mainly by the labours of eminent mathematical scientists, from Ampère down to Maxwell, which are usually supposed to be within the reach of none but mathematicians, but which I have thought could be to a great extent stripped of their usual symbolical dress, and in their naked simplicity made to appeal to the sympathies of the many (like Phryne to her judges, perhaps, but I don't remember what she was up for). Let not, however, the reader (if he belong to the many) imagine that thinking can be dispensed with; there is no royal road to knowledge, and hard thinking and rigid fixation of ideas is required. Even the machinery of the mathematician, so great an assistance when made to work, requires severe training on the part of the operator to make it work. But earnest students, if they will not or cannot learn the mathematical methods, need not therefore be discouraged, for the name of Faraday will shine forth to the end of time as a beacon of hope and encouragement to them. He was no mathematician, yet achieved results apparently only attainable by such methods. It need not be supposed that he had the peculiar brains of a calculating boy, able to do long sums "in his head" by special methods of his own. The work was of quite a different kind, and probably Faraday could never have made an ordinary mathematician with the best of training. In fact, mathematical reasoning does not necessarily involve any calculating in the usual sense, though it is, of course, greatly assisted thereby sometimes; and as for the use of symbols, they are merely a sort of shorthand to assist the memory, which even those who openly contemn mathematical methods are glad to use so far as they can make them out, in the expression of Ohm's law for instance, to avoid spinning a long yarn. In the following no symbolisation much more complex is used. Portions in [ ]'s are digressions, not absolutely essential for continuity.

To introduce the subject, we start with the case of a long, straight cylindrical wire, conveying a steady current C. The magnetic force is known to be of strength $\frac{2C}{r}$ in electromagnetic measure at distance r from the axis outside the wire, and its direction to be perpendicular to r and to the axis. This, however, does not settle in which direction along the perpendicular the force acts, and so a rule becomes necessary. Look along the axis in the direction the current is going, the magnetic force is then in the direction of right-handed rotation about the axis. This rule, or any equivalent one, is the key to all the directional relations in electromagnetism. The hands of a watch, viewed from the front (they cannot be seen from the back) revolve right-handedly, so that if we imagine the watch-face to be a section of the wire, and the current to go from face to back, the magnetic force is in the direction of the rotation of the hands.

The force being of the same strength at the same distance

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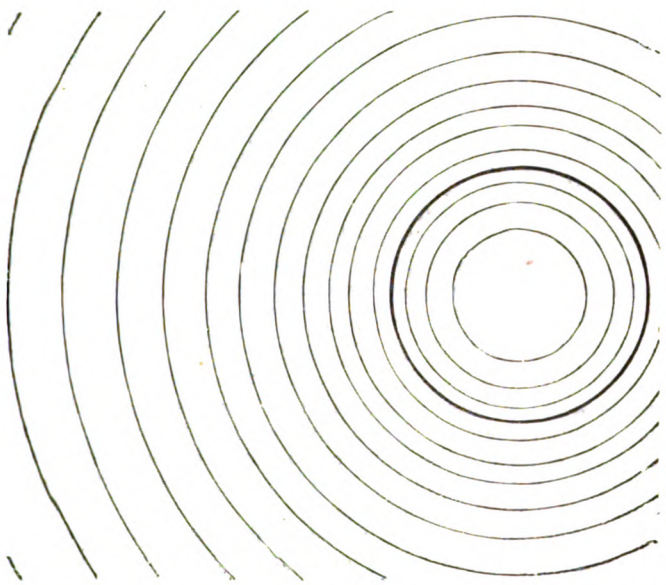
from the axis, a line of force is a circle embracing the axis, and the axis is perpendicular to its plane. Confining ourselves now to a single plane normal to the axis, all circles centered upon the point where the axis cuts the plane are therefore lines of force. But if we wish to show graphically the strength of force as well as its direction at any place, the best way is to draw the lines so that their density or closeness together shall be proportional to the strength of force at the place. In our present case this gives us the rule that the radii of successive circles should increase geometrically.

Within the wire, the magnetic force is known to be of strength $\frac{2\,Cr}{a^2}$ at distance r from the axis, a being the radius of the wire, and, like the external force, perpendicular to r and to the axis, with right-handed rotation. At the surface, the two expressions become the same, viz., $\frac{2\,C}{a}$. The force being now directly as r, a different rule is required to make the density of lines of force proportional to the force. The squares of the radii of successive circles must form an arithmetical progression. Further, the scale outside and within should be the same, so we require a relation between the common ratio of consecutive radii outside, and the common difference of squares of consecutive radii within. [If ρ is the external ratio and d the internal common difference, $d = 2\,a^2 \log.\ \rho$. For let a_1 be the radius of first circle outside, and a_0 that of first inside, a_0 a and a_1 being thus consecutive, we must have, k being any constant,



$$\frac{k}{a_1 - a} = \frac{1}{a_1 - a} \cdot \int_a^{a_1} \frac{2\,C\,dr}{r} \therefore k = 2\,C \log.\ \frac{a_1}{a} = 2\,C \log.\ \rho$$

$$\text{Also, } \frac{k}{a - a_0} = \frac{1}{a - a_0} \int_{a_0}^{a} \frac{2\,Cr}{a^2}\,dr \therefore k = C\,\frac{a^2 - a_0^2}{a^2} = C\,\frac{d}{a^2}$$

Therefore, $d = 2\,a^2 \log.\ \rho$.]

In the figure, the common difference d is chosen $= 1$ and the radius $a = 2$, so that the three lines within the wire (which is bounded by the thick circle) have radii 1, $\sqrt{2}$, $\sqrt{3}$. The circle $a = \sqrt{4}$ is also a line of force, and the rest have radii 2ρ, $2\rho^2$, $2\rho^3$, &c., where $1 = 8 \log._\epsilon \rho$.

Let us now examine a general property of this system of magnetic force. If we place a unit magnetic pole at any point in the external field, and suppose that it can move freely under the influence of the magnetic force of the current, and that no other forces act upon it, the pole will evidently describe a circle about the axis, and the work done by the force on the pole during a complete revolution will be force $\times$ distance $= \frac{2\,C}{r} \times 2\,\pi\,r = 4\,\pi\,C$. And evidently in moving through any stated fraction of the complete circle, the work will be the same fraction of $4\,\pi\,C$. Observe that this is the same at any distance from the wire, and the work depends only upon the angle turned through. Also, if the pole be moved either radially from the axis, or parallel to the axis, there is no work done, because there is no force in those directions. Let now the pole be carried from any one place to any other by any path, its motion at any point of the path may be compounded of a motion *from* the axis, a second *parallel* to it, and a third *round* it. Since the last alone involves the performance of work it follows that the work done on the pole between any two points by any path is $2\,C \times$ angle turned through in the positive or right-handed direction, between the first and last positions.

Now, limiting our consideration to motion in completely closed paths, if the curve embraces the wire once, the line integral of the force once round the closed curve is $4\,\pi\,C$, and if it goes round n times (in + direction) it is $n \times 4\,\pi\,C$. But if the closed path does not embrace the current, or if embracing it a certain number of times in the + it embraces it the same number of times in the — direction, so that if the path were a string it could be drawn off the wire without cutting it, the line-integral is *nil*. In this case the angle turned through about the axis comes to nothing when we return to the starting-point.

Transferring our attention next to the current passing through the closed curve, we see that when the line-integral is *nil* the current is *nil*, and when the line-integral is $4\,\pi\,C$ the total current through the curve is C, and when it is $n \times 4\,\pi\,C$ the total current is $n\,C$. This may be all summed up in one statement. The line-integral of the magnetic force once round any closed curve equals $4\pi \times$ total current through the curve.

Let us now see whether the force within the wire follows the same rule. First let the unit pole follow a line of force once round the axis at distance r. The work done by the force = force $\times$ distance $= \frac{2\,C\,r}{a^2} \times 2\,\pi\,r = 4\,\pi\,\frac{C\,r^2}{a^2}$. Now, $\frac{C}{\pi\,a^2}$ is the current density, and $\pi\,r^2$ is the area enclosed by the line of force, so that $\frac{C\,r^2}{a^2}$ is the current through the closed curve, and, as before, line-integral of force $= 4\,\pi \times$ current enclosed. And, since there is no force parallel to, or radially from the axis, the same statement is true for any closed path whatever within the wire; and, being true outside the wire, is also true for any path partly within and partly without, and so, in fact, is universally true.

Now we shall generalise the statement. It is not merely true for the magnetic force of a straight current, but also for any possible system of magnetic force. It is the fundamental relation between magnetic force and electric current. Given, then, a system of magnetic force, we may find the corresponding current system by the following process. Required the current at any point, P. Through P draw any straight line, and describe a small plane closed curve about it as an axis. Find the line-integral of the magnetic force along the curve once round the axis, or the work done upon a unit pole during one rotation. The result is $4\,\pi$ times the current through the curve. Divide by the area enclosed, and we obviously get $4\,\pi$ times the component of the current density in the direction of the axis.

Let the axis turn about the point P as fulcrum into any other position, the closed curve moving with it as if rigidly attached; the line-integral in the new position will be $4\,\pi \times$ current through curve in the new position. There is a certain direction of the axis for which the line-integral is a maximum; this direction is that of the actual current at P, and the maximum line-integral divided by $4\,\pi$ times the area is the actual current density. We may conveniently take the area for unit area, so as to get the current density at once. Or, we may find the current density by the above process in any three rectangular directions, and their resultant will be the actual current density.

This process, by which we derive current from the magnetic force, is of great importance in physics. Especially so in electro-magnetism, where there are several quantities bearing to one another the same relation. When one vector or

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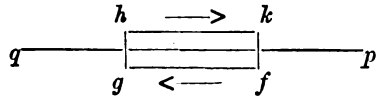
directed quantity, B, is related to another vector, C, so that the line-integral of B *round* any closed curve equals the integral of C *through* the curve, the vector C is called the curl of the vector B. The term curl was proposed by Maxwell, though he does not appear to have used it much. Its appropriateness is evident on considering the method by which we derive C, the curl of B, from B itself; and, as a name for the operation is wanted for descriptive purposes, it will be used in the following. Thus, current $= 4\pi \times$ curl of magnetic force.

[The presence of the factor 4π is due to the definition of a unit magnetic pole. If we defined the unit pole so that the unit amount of force emanated from it, the force at distance r would be $\frac{1}{4\pi r^2}$, since $4\pi r^2$ is the area of the spherical surface over which the force is spread at distance r. Then we should have current = curl of magnetic force. And if we had a similar definition of the unit of free electricity, we should have the electric force at a surface numerically equal to the surface density, instead of, as at present, 4π times as much. But the actual definitions chosen make the force at distance $r = \frac{1}{r^2}$. This looks simpler, but it leads to the awkward result that mathematical investigations, both in electrostatics and in electro-magnetism, are filled with 4π's, and $\frac{1}{4\pi}$'s. Sometimes we multiply, at other times divide. They would mostly be got rid of by defining electric and magnetic forces as fluxes in the same manner as the electric current, for a current, C, spreading from a centre produces current density $\frac{C}{4\pi r^2}$ at distance r, and not $\frac{C}{r^2}$. At the same time, 4π would make its appearance in certain cases where it is now absent, such as in spherical problems, and its presence there would be perfectly natural, 4π being the area of unit sphere.]

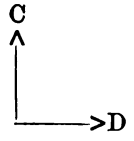
To show that the idea of the curl is not without practical utility, even to non-mathematicians, we may employ the process to find the distribution of current for fresh systems of magnetic force, starting from the one already treated. Call the magnetic force of a straight current B, and the current C, this being now the current density. We know that $4\pi C =$ curl of B. What is next the curl of C? This is easily found. Outside the wire C is *nil*, therefore so is its curl. Within the wire C is uniform, so that its curl is also *nil* there. But in passing through the surface, C suddenly changes from C in the wire to 0 outside, so there *is* surface-curl. Let



pq be a straight line upon the surface in the direction of C. Let the closed curve of integration be the rectangle $fghk$, consisting of two straight lines fg and hk parallel to the surface, and very near it, with two connecting pieces gh and kf; and let the rectangle be perpendicular to the surface. We have to find the line-integral of C once round $fghk$. Evidently the portion fg contributes $fg \times C$, and the rest nothing; the connecting pieces because they are perpendicular to C, the other because it is outside the current. $fg \times C$ is, therefore, the total amount of the curl of C passing through the rectangle, *i.e.*, it is of strength C per unit of length along pq. Shorten the connecting pieces indefinitely, we have still the same result, so that the curl of C is finally a vector quantity of amount C per unit of length of pq, drawn upon the surface at right angles to the current. Let the current go from right to left, then its curl is directed downwards through the paper, that is, in the same direction as the magnetic force. The same is true for every point of the surface, so that the lines of the curl of C are circles upon the surface, centred upon the axis.

Let, now, C represent the magnetic force in a new system, *i.e.*, the magnetic force is confined to the space within a long cylinder, and is everywhere parallel to its axis, and of uniform strength C. We have found the curl of C, so we know the corresponding current distribution. It consists of a cylindrical current sheet, the current circulating round the axis, its amount per unit length of cylinder being $\frac{C}{4\pi}$. This is the case of a long solenoidal coil of a single layer of wire; if the current per unit length be C, the magnetic force is *nil* outside, and of uniform strength $4\pi C$ within, parallel to the axis. Put on more layers of wire, and we have simply to add on the additional magnetic force, and the result is that the magnetic force is $4\pi C$ (where C is the *total* current round unit of length) everywhere inside the innermost layer, and falls from $4\pi C$ to 0 in passing through the layers to the external space.

For another example, let us find the curl of the current in the last case. Start with a cylindrical current of strength Ct per unit length, and let the small thickness of the current layer be t, so that the current density is C. We found before that to deduce the curl of a vector C when it suddenly changed from C to 0 in passing through a surface, we had merely to turn it through a right angle upon the surface, and we obtained the new vector. The direction of rotation must, however, be carefully attended to. If we look down upon the surface, and the direction of C is as shown, then its curl, D, goes from left to right. Now our current sheet has two surfaces, inside and outside. In passing from the current to outer space, we therefore rotate one way through a right angle, thus bringing us parallel to the axis; and in passing from the current to inner space we rotate the other way through a right angle, bringing us also parallel to the axis, but pointing in the reverse direction. Since we get the same result everywhere, the curl of C consists of two tubular vector systems separated by the thickness t, of equal strength, but oppositely directed.



If, then, C represents the magnetic force in a new system, we have the following:—Two thin concentric tubes, distance between them $= t$, a current of total strength

$$C \times \frac{2\pi a}{4\pi} = \frac{Ca}{2},$$

where a is the mean radius of the tubes, straight along the outer tube, returning by the inner one. There is no magnetic force within the inner or without the outer tube. Between them, the magnetic force is in circles about the common axis, and is of mean strength C.

Further application of the same process only gives rise to repetitions in a more complex form of the last two examples, multiplications of cylindrical and straight tubular currents alternately, and we need only notice the first of the series. If we find the curl of the current in the last case, and then transform current into magnetic force, we obtain four cylindrical current sheets. In the outer and innermost the current circulates round the axis one way, in the two intermediate the other way. The magnetic force is parallel to the axis between the first and second, and also between the third and fourth, but oppositely directed, and is *nil* everywhere else.

We see that the process of deriving fresh distributions from a known one by curling may be continued. We have a series of vector systems, A B C, &c., of which any one is the curl of the preceding; and, taking any one to represent magnetic force, the following one is the corresponding current, excepting a constant factor. It will readily suggest itself that the series may be continued the other way. This is true, but is not so easily managed. The reverse operation to finding the curl of a vector, viz., to find the vector whose curl is a given vector, is more difficult than the direct, though of not less interest or importance. This matter, and some other relations between current and magnetic force, will form the subject of a following article.

ERRATA.—Page 607, last Vol., Nov. 11, 1882—In last three lines of first column, and in first line of second column, for C read K wherever it occurs.

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CURRENT FORCE AND ENERGY.—II.

BY JOHN T. SPRAGUE.

(CONTINUED FROM VOL. IX., P. 584.)

It was not sufficiently explained in the article, p. 583, Vol. IX., that the definition of *force*, as representing the *square root of energy*, applies to the *potential* energy, not to energy developed, and that it refers also to unit conditions, that is to say, to force acting in a unit conductor. Here the hydraulic and electric analogy fails to some extent. We can have a water current without a conductor. The unit conditions stated, of a stream issuing from an opening of one circular inch, involve no conductor and no resistance, and the issuing stream carries with it the energy due to its velocity. But a conductor is essential to the electric current, and the energy is wholly expended in the circuit (for even external work constitutes a part of, or a condition of the circuit itself). We are, therefore, compelled to work under the consequent limitations. The result is that with "head of water" we can never have a current greater than the rate due to force. But in electricity we can, and then the energy developed will be greater than that potential in the force. This results from the fact that gravitation is a real force, while E.M.F. is an artificial one, of which the consideration of unit resistance is an integral part. It is only the theoretical force capable of sending unit current through unit conductor.

The proportion of energy which becomes developed as work is as $E^2 \div \frac{E}{R^2C}$, which comes to $E^2 \div R$, and the reason is that the true resistance, which varies as the square of C in any conductor, may be regarded as a counter, or — E.M.F., because it reduces current or velocity. This is clearly recognised in hydraulics where frictional resistances are reckoned in terms of the head of water absorbed in overcoming them. A glance at the table, p. 583, will show this, and explain how part of the energy due to "force," as expressed in terms of square root of head, becomes kinetic and the rest remains potential. If we take for unit such an opening as allows 1lb. water per second to issue under unit force we should have 3lb. under $M \div 3$, line 3, which gives Col. VI. $144 \times 3 = 432$ft.-lbs. of energy, or 27 units. If we now add piping such as will reduce the current to 1 we have only 1lb. falling 144ft., which is 9 units of energy kinetic. Now, although the current is only that due to M 1, we cannot express the action as due to $M\,3 - 2 = 1$, because this would only give us 16ft.-lbs. or 1 unit kinetic energy; but we have 9 units, and the difference between 1 and 9 has disappeared in the form of friction in the pipe, converted into heat. The same occurs in electricity; but, as just remarked, the conditions are somewhat different, and we must look further before we find what expression of the vanished energy can be used as — force or as resistance.

We have brought the water current to conditions closely analogous to those of the electric current, and to Ohm's formulæ, but we require something which will represent the electric circuit. There is a great difficulty here, because while the conductors agree in both cases by varying as their areas, this is not so as to the work expended in them as friction or heat. In pipes this is two fold. 1. Skin or surface friction, varying as the surface, that is as *square root of area*. 2. Viscosity of the water itself, which necessarily varies as the *area*. Both vary also as the length and as the square of the current or velocity. In wires there is only one friction or energy expended in molecular motions, and this is as the area simply, and the same as with water as to length and current. This difficulty may be partially overcome by considering any increase of conductor in the same manner as it is wise to consider wires; to disregard actual sizes, but to consider any increase as meaning so many unit conductors added, that is, in order to double the area of the water current from a 1 inch pipe, instead of increasing the pipe to 2 circular inches (that is a diameter of 1·4 inch), we must insert a second inch pipe, side by side, carrying the same current, and expending the same energy as the first. In the same way we should consider wires, not as to their gauges and diameters, but by the number of unit wires of 1 mil. circular ($\frac{1}{1000}$ of an inch) to which they are equivalent, which is in fact their area in circular inch as given by d^2. We must now add a definition of length to constitute a conductor of unit capacity in order that we may include the resistance as friction, &c., essential to the passage of current, and upon which, therefore, the conducting capacity will depend.

Resistance.—The definition of Ohm's law is that current is proportionally as the force, and inversely as the resistance. $C = E \div R$. What is resistance? Common sense, universal mechanical experience reply *that which resists*, that is to say which stops or diminishes motion, that which absorbs energy in the overcoming it. These two definitions are the same in fact and in theory, but they can be made to work out in very different fashion. For this reason I put them again distinctly as if different.

Resistance is { (A) that which opposes or reduces current. (B) that which absorbs energy.

Looked at as A resistance is a counter, or force, and as such it must be expressed as $\sqrt{energy}$. Looked at as B it is work, and it must be expressed as simple *energy*.

The *ohm* is the unit of electric resistance; in what way is it related to these definitions? Inasmuch as the ohm is a measure of a part of the circuit, and as a conductor is absolutely essential to the passage of current, and holds to the electric current the same relation as the pipe does to water, it seems we should primarily regard it as a unit *conductor*, not a unit *resistance*; it would be considered absurd to call a pipe a "resistance" to a water current. But if we measure the circuit in terms of conduction, it is evident that, calling the unit conductor A, the formula for current would be $E \times A = C$; but, inasmuch as increasing length would reduce conducting power, the value of A would have to be calculated inversely to its length or number of unit conductors added lengthwise. This would be inconvenient, and, therefore, an arithmetical strategem is employed. The result is the same, whether we multiply by a number or divide by the reciprocal of the number (the reciprocal being 1 divided by the number). Therefore, we may transform A, the conducting capacity, into R, its reciprocal, and then the current formula becomes $E \div R = C$. Now, every conductor absorbs energy in transmitting current, and this is a true *resistance*. We must, therefore, set up a unit value of this energy or resistance in terms of the unit system, that is, this unit must be the amount of energy absorbed by the unit conductor when transmitting unit current. This unit energy, tending to diminish current, is, therefore, in inverse relation to force, and takes its part in the formulæ exactly as does the reciprocal of conducting capacity (which, in fact, is determined in value by the consequent reduction of conducting capacity). Hence the symbol R includes both these; it is the reciprocal of conduction, and it is also the resistance.

But these relations, simple enough and clear as to the unit value, lose their simplicity the moment we pass to larger currents; then resistance in its sense (B) increases in the ratio of the squares. We cannot well divide E, the force which increases as current, by an R, which increases as the squares, to obtain a result (C) proportional to the force and the conducting capacity. To do this we must express this resistance in its (A) sense, that is to say as an inverse or counter force. This means that we must express it by its square root, as with the force. The necessary unit of energy as resistance or work is derived from $C^2 \times R$, and in the electric system it gives us a value in ergs 10^7; in the practical system we have the *joulad* expressed as a power by the volt ampere, proposed to be called the watt. If we symbolise this by J the formulæ gives us—

$$\frac{E}{R} = \begin{cases} C\ \frac{\text{Volt}}{\text{Ohm}} \\ J^2 \end{cases} = \begin{cases} \text{Ampere} \\ \text{Joulad}^2. \end{cases}$$

From these considerations we can define the ohm as a unit conductor, in which unit energy is absorbed when unit current passes, and generally as the square of the current passing. It is a resistance only in a mathematical sense.

When it is stated that in electricity a resistance, say 1 ohm, is the same for all currents, "the same for a circuit working one lamp as for working 100 or 1,000," we are simply deal-

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ing with mathematical legerdemain. The statement is utterly absurd; no such resistance is to be found throughout nature. It only becomes true when we recognise the "fact that in transmitting electrical energy the conductor itself retains a certain amount proportional to that transmitted, which makes its appearance therein in the form of heat," and the further fact that these energies are not only as the 1, 100, and 1,000, but as the squares of those numbers if the same conductor is used. The common statement, so often made, that electricians look upon it as an established truth, is utterly unmeaning when we consider the ohm as *resistance*. It is explainable when we see that it really means, in the way it is used, the square root of the resistance converted into an artificial counter force, to match the artificial force created from the square root of the active energy.

To carry out our analogy we now require a pipe which shall fulfil for water currents the same conditions as the unit ohm does for electricity. It must be, to carry on the system, a pipe of 1in. circular area of such length as to pass a unit current = 1 gallon per second under unit head 16ft., and it must be of such length and material as to absorb unit energy = 16-foot pounds in friction when unit current passes. Now here we come to a problem more intricate than that of the ohm. The whole energy of unit current in electricity is expended in the unit circuit, because the circuit is a closed circle, and no electricity leaves it, nor has electricity any *momentum*. But a ponderable fluid, as water, has momentum, and as long as we treat the current as derived from a head of water the unit current when it leaves the unit conductor will still retain its unit momentum or force. This is of necessity, because if the unit conductor absorbed the whole energy there could be no current. This can be met by treating the current as due to a hydraulic engine acting upon a closed circle of pipe, but its consequence at present is that we can only define our unit conductor as that which would allow unit current to pass under doubled head, of which one head, 16ft., is employed in giving the final velocity, and the other head, also 16ft., is employed in supplying unit energy, 16ft.-lb., to overcome the resistance. As a consequence, we could not employ for water-currents a single and simple relation like Ohm's formulæ, though the same principle is in operation; we should have to divide it into two parts, one of which would represent the current and its energy in the pipe, and the other the energy carried by the issuing stream. It is only the first part which concerns the electric analogy, and what we have to consider is, what length of 1in. pipe would consume in friction the energy of unit head, that is to say 16ft.-lb., while passing a unit current of one gallon per second; that pipe would also allow the unit current to pass under a double head, because the formula would be $\frac{1M}{1C} = 1C + 1M \times 1A = 1C$, the true resistance or energy absorbed by friction being expressed in the first part exactly as in the electric formula, while the issuing current would be represented by the second. The actual pipe corresponding to this formula would depend upon the nature of its inner surface, but taking the ordinary formulæ for transmission of water through iron pipes, it is approximately one yard of 1in. pipe, which, therefore, corresponds in all respects for water currents to the conductor of 1 ohm resistance for electric currents.

The analogy would be more perfect if worked out for the case of a circulating current from a hydraulic engine with a circuit of piping, but this would not have furnished the evidence that E.M.F. expressed in volts is the analogue of the hydraulic force "square root of head" which was necessary to explain what I mean by saying that these artificial forces are derived from energy. I may add that various writers have worked at the same idea, but have been led in a different direction by giving a different expression to "force." They have claimed that the true electric *force* is the attraction between two surfaces, and they are certainly right, because this attraction is exactly analogous to pressure, and therefore to head of water. But whether we call it E.M.F., or potential, or tension, the volt expresses, not this attraction, but its square root, corresponding to the square root of head of water or static pressure. The result is that the writers referred to call that *force* which does not answer to the definition of force, but which does answer to the definition of *energy*, either under unit conditions, or potential as well as kinetic.

CORRESPONDENCE.

CHARGING SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the arrangement by Mr. Kent for giving warning of the reversal of current in charging accumulators, which was inserted in your last number, there is no doubt that it is a very simple one as an alarum for mere reversal. But Mr. Kent does not seem to take into consideration the fact that Mr. Crawley's arrangement, though not entirely self-acting, also gives warning of the weakening or strengthening of the charging current, which is a very great advantage, particularly in carrying out experiments with new forms of cells. Should the current happen to fall below a certain limit, or to reverse, thus allowing the lower spring to make contact and give the alarm, it is an easy matter when altering the current to replace the spring. It is obvious that the top spring does not again require to be touched after having been once set to ring the bell when the current strengthens beyond a given degree. I may add that in practice this instrument can be readily adjusted to show differences of less than half an ampere above or below the proper charging current.—Yours, &c., E. C. RIMINGTON.

School of Electrical Engineering, 12, Princes-street, Hanover-square.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the letter from me on the above, published in your last, you have omitted the word *or* in line 15. It should be out of bell to earth *or* on to negative pole of first accumulator.—Yours, &c., H. A. KENT.

154, Culford-road, N., November 13, 1882.

ELECTRIC TRICYCLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I can assure your correspondent, Mr. MacDonald, that there was no disposition on my part to "chuckle" at the electricians and their tricycles. My letter was written with the simple object of showing the rocks and quicksands ahead, and I can only assure your correspondent that I am very pleased that he has found a practical way out of the difficulty. We have the authority of Dan O'Connell's statement that it is easy to drive a coach and horses through an Act of Parliament, but I think this is the first case of a tricycle being driven through the Locomotive Roads Act. I am sure it would be interesting to your readers if Mr. MacDonald will favour us with a description of the motor he proposes to use, and what his idea is as to the cost of a tricycle fitted according to his plan.—Yours, &c.,

CHANCERY LANE.

ELECTRICAL TRANSMISSION OF ENERGY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I happened yesterday to be talking to an electrician when the conversation turned upon the experiment of M. Marcel Deprez in "Electrical Transmission of Energy," made at the Munich Electrical Exhibition, and quoted, as I see, in *The Electrician* of Nov. 4th. The gentleman in question was so convinced that the transmission could never have taken place that my hesitation to join at once in his incredu-

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lity was met by a somewhat contemptuous, but not in such cases unprecedented, reference to "all the text-books on the subject," which I was advised to consult. As further argument was not forthcoming, I determined to find out what real ground there was for rejecting altogether the experiment of M. Marcel Deprez, and to form an idea of the probability of the case as stated being approximately true.

Taking, therefore, the equation of energy applicable to a single-circuit system,

$$C^2 R - C E = - W,$$

in which C is the current, R is the total resistance, E is the electromotive force of the generating machine, and W is the entire work given out by the other machine, all in electrical units. I may remark that in this particular case W = 373 and R = 1900; so that the equation has only two unknowns, C and E, but C is involved to the second power. The alternation of the signs of the terms shows that the two values of C are, when real, both positive. Let us now write the above equation in the following forms:—

$$C = \frac{E}{2R} \pm \frac{\sqrt{E^2 - 4RW}}{2R}. \quad \ldots\ldots\ldots \quad (\alpha)$$

$$1 - \frac{CR}{E} = \frac{W}{EC}, \text{ which is clearly the efficiency.} \quad (\beta)$$

Call the efficiency a.

The equation (α) at once shows that C cannot have a rational value unless E^2 is as large as 4 R W or larger.

If $E^2 = 4RW$, we can find E from this equation,

$$E = \sqrt{4 \times 1900 \times 373} = 1684 \text{ volts about.}$$

In which case

$$C = \frac{E}{2R} = \frac{1684}{3800} = \cdot 443 \text{ amperes.}$$

So that until the electromotive force of the generating machine reaches 1684 *volts, and the current is* ·443 *amperes, the* 373 *watts cannot be transmitted at all through the* 1900 *ohms of total resistance.*

The efficiency $a = 1 - \frac{CR}{E}$, from which, by substituting for C its value in (α), we have

$$a = \tfrac{1}{2} \mp \frac{\sqrt{E^2 - 4RW}}{2E}, \quad \ldots\ldots \quad (\gamma)$$

$\therefore$ the efficiency is $\frac{1}{2}$ in this case of $E^2 = 4RW$.

But we may write this equation (γ).

$$E^2 = \frac{RW}{a(1-a)}, \quad \ldots\ldots\ldots \quad (\delta)$$

which is a convenient form to deduce E when the efficiency is given. Suppose the efficiency is $\frac{60}{100} = \frac{3}{5}$.

Then $$E^2 = \frac{1900 \times 373}{\frac{3}{5} \times \frac{2}{5}} = \frac{1900 \times 373 \times 25}{6},$$

or E = 1718 volts about.

The probability of M. Marcel Deprez's statements being true rests, therefore, upon the probability of his having found a machine to generate the above electromotive forces, which is probably what my friend would say is what he meant all the while.—Yours, &c., THOMAS H. BLAKESLEY.

November 10th, 1882.

LAMPS FOR CARRIAGE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could the lamps of a two-horse carriage be lit by electricity, either arc or incandescent light?

I require a very strong light for driving fast on a dangerous road at night, and oil lamps are not bright enough. I should feel much obliged if you will answer this question in your interesting paper.—Yours, &c., W. W.

PHYSICAL SOCIETY—Nov. 11.

Profesor CLIFTON, President, in the chair.

Professor ROWLAND, of Baltimore, exhibited a number of his new concave gratings for giving a diffraction spectrum. He explained the theory of their action. Gratings can be ruled on any surface of the lines, are at a proper distance apart, and of the proper form. The best surface, however, is a cylindrical or spherical one. The gratings are solid slabs of polished speculum metal, ruled with lines equidistant by a special machine of Professor Rowland's invention. An account of this machine will be published shortly. The number of lines per inch varied in the specimens shown from 5,000 to 42,000; but higher numbers can be engraved by the cutting diamond. One great advantage of their use is that the relative wave-lengths try the micrometer with great accuracy. The author has designed an ingenious mechanical arrangement for keeping the photographic plates in focus. In this way photographs of great distinctness may be obtained. Professor Rowland exhibited some 10in. long, which showed the E line doubled and the large B group very clearly. Lines are divided by this method which have never been divided before, and the work of photographing takes a mere fraction of the time formerly required. A photographic plate, sensitive throughout its length, is got by means of a mixture of locene, iodised collodion, and bromised collodion. Professor Rowland and Captain Abney, R.E., are at present engaged in preparing a new map of the whole spectrum with a focus of 18ft. In reply to Mr. Hilgar, F.R.A.S., he stated that if the metal is the true speculum metal used by Lord Rosse it would stand the effects of climate he thought; but if too much copper were put in it might not. In reply to Mr. Warren de la Rue he said that 42,000 was the largest number of lines he had yet required to engrave on the metal.

Professor GUTHRIE read a letter from Captain Abney pointing out that Professor Rowland's plates gave clearer spectra than any others; they were free from "ghosts" caused by periodicity in the ruling, and the speculum metal had no particular absorption.

Professor DEWAR, F.R.S., observed that Professor Liveing and he had been engaged for three years past in preparing a map of the ultra-violet spectrum, which would soon be published. He considered the concave gratings to make a new departure in the subject, and that they would have greatly facilitated the preparation of his map.

Mr. W. BROWN then read a paper on the "Conservation of Energy and Central Forces." He showed that the doctrine of the conservation of energy necessarily involved central forces, and could not be proved unless on the assumption of a system of central forces. This involved the hypothesis of Boscovich, that matter consists of a collection of centres of force, and the author criticised the objections of Clerk Maxwell, Tait, and others to Boscovich's theory. The paper will appear in the *Transactions* of the Society.

Professor S. P. THOMPSON read some "Historical Notes on Physics," in which he showed that the voltaic arc between carbon points was produced by a Mr. Etienne Gaspar Robertson (whose name indicates a Scotch origin) at Paris in 1802. This reference is found in the *Journal de Paris* for that year. Laboratory notebooks at the Royal Institution, however, are said to show that Davy experimented with the arc quite as early. The experiment usually attributed to Franklin of exhausting air from a vessel of water "off the boil" and causing it to boil afresh is found in Boyle's "New Experiments Touching the Spring of the Air." Professor Thompson also exhibited an early Reis telephone, made by Philip Reis in 1861 at Frankfort, and designed to transmit speech. It was modelled on the human ear, one form of transmitter being a rudely-carved wooden ear, with a tympan having a platinum wire behind, hard pressed against a platinum-tipped adjustable spring. Professor Thompson showed by various proofs that words were actually sent by that and similar apparatus.

INDIAN TELEGRAPH SERVICE.—Notice is given that the Secretary of State for India will, in the summer of 1885, offer two appointments in the Indian Telegraph Department to students entering the Royal Indian Engineering College at Cooper's Hill, near Staines, in September, 1883. Candidates for admission to the college must on the 1st of July next be over 17 and under 21 years old, and must give satisfactory proof of having received a fair general education. Further particulars can be obtained by applying in writing to the Secretary, Public Works Department, India Office, S.W., or to the President of the College.

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THE ELECTRICIAN.

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SCIENCE CLASSES EXAMINATION.

The season of science classes is now at its height, and before many months are over we shall see the fruits thereof being gathered. By fruits we mean the results of examinations, which have come to be regarded as the end and aim of all learning, scientific and other. We do not ourselves so regard them, as we have said before on more than one occasion; but such is the current view, and we must take it at its own estimate. If all that is to be got out of science classes were a certain percentage, low or high, of pass certificates and prize awards, then science would, indeed, be in evil case. Happily, it has not arrived at that stage yet, and we believe it never will. But the fact is undeniable that amongst a large number of students the ostensible aim is this, and nothing else but this. At all events, this is the immediate aim, practical and ulterior objects being for the moment subordinated.

That the attainment of these objects is not always furthered, and is sometimes hindered, by a course of study directed to the passing of an examination—or a series of examinations, for there are a great number to compete in—is almost certain; but the prevalence of the system, and the market value of the honours secured under it, compel obedience to its prescribed course, only very adventurous spirits daring to travel by any other road. The fault is not theirs; the system has grown, and is fast taking root, like some novel cult, under patronage of the high priests — who are first shy, then sly, and then among its warmest devotees. The sacred doors of the examination room are supposed to be the portals to fame and a great career. All hope abandon—the presiding geniuses are evermore decreeing—ye that do not enter here; and the crowd grows thicker and thicker who throng the highroad thereto. That many a pilgrim fails to gain admittance who ought to be respectfully welcomed is, perhaps, not much to be lamented. His very demerits, for that kind of scramble, may serve him in good stead hereafter for toil more profitable. But it is to be regretted, and greatly, that many who have no sort of title to enter do enter and pass out, bearing unimpeachable testimonials that they are true sheep when in reality they are but worthless goats. Not until they have done themselves perhaps irreparable injury, and deceived a number of innocent persons besides, is the delusion found out.

We speak of it as a delusion, because it would be unfair to call it an imposture. The imposition, if there is any, is inside the temple, not outside. The wise men know very well by this time that their divinations count for hardly anything; but the oracles are of their own contrivance, and to alter them might shake the very foundations of the faith. Reform from that quarter is therefore not, perhaps, to be looked for; nor do we look for it by means of attacks directed against either the men or the system. There are good points in both. Rather by the results would we test them; not by disparaging the Gods, but by depreciating their works may we hope to bring the people back to reason and the right way.

Yet even among the hierarchy of examiners we do find that they occasionally confess to doubt and misgiving as to the efficacy of the system they are required to administer. Professor de Morgan declared that he could judge the candidate's capabilities by a brief personal inspection of his ordinary work far better than by examining papers representing the work of a whole week. If professional examiners spoke their mind, most of them would probably say the same thing. The real test of working capacity is left to be made by the employers later on. This is a fact which we commend to the notice of all such employers of technical labour. If they take note of it they will not attach too much value to examination certificates, nor too little to otherwise elegible persons who do not possess them. In due time, if this maxim were kept in mind, there would be no need to warn students against attempting to enter any or every profession by feats of mental legerdemain. Their sterling qualities would be tested otherwise, and on the rational as well as practical lines indicated in the remark of the eminent man above referred to.

One result of these examinations falling into disrepute—or, rather, let us say of their being cleared of the superstitions in which they are surrounded—would be that teachers would then have a chance of becoming famous. This they might do, if they have the right metal in them, even now, by working in defiance of examinations. To a large extent the teaching function has been superseded by the cramming. The so-called modern teacher is a sort of juggler who, having mastered the mysteries of the oracles, is willing to impart the secret to others for a handsome consideration. There is, we are told, a good deal of money

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to be earned by this kind of teaching, which may be fitly described as the art of making ignorance to look knowing. But there is not much fame and little honour to be got by it. Such talents would pay better, as talents were wont to pay, we imagine, if they were invested in the old-fashioned establishment. Some people predict that crammer will grow altogether too clever for examiner. We sincerely hope he may. He is as much of a true prophet as the magicians of the Royal household, though that is not saying much; and when he has beaten them with their own enchantments deliverance from bondage may be near at hand.

We are well aware that nothing we can say in condemnation of this system is likely to make an impression upon it—it must wear itself out, or become too intolerable to be borne. But there are, as we have already hinted, some practical considerations which teachers and examiners, as well as students and employers, would do well to bear in mind in the interests of all alike. We speak especially of electrical science teaching, and our remarks are suggested by certain examination papers which lately came under our notice. Some of the questions seemed to presuppose that the candidates had been trained with a view to becoming theoretical electricians, and the mathematical workings were consequently very stiff. This we contend is a complete mistake. The amount of mathematical knowledge required for practical electrical engineering is not very great. It is the practical part of the profession that students want to learn, and employers require them to master. We shall not be suspected of underrating mathematics or the study of theoretical electricity; but we do object to their occupying a prominent place in the examiners' papers. The time devoted by the teacher to qualify his pupils to answer such questions would be far more usefully employed in teaching the practical part of other branches of science, several of which are now seen to play an important part in electrical engineering. We hope to return to this subject on a future occasion.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

VIII.

We give in this number two figures showing the connections for taking the capacity test with two different arrangements, as proposed in our last issue. Referring to the particular subject considered in the closing remarks, it will be noticed that the shunt is represented in both figures as connected directly to the galvanometer coils. In the galvanometer as used in the testing room these terminals are at the base, and here the shunt leads would really be joined. They are not, however, always connected directly, but are sometimes brought up to other terminals, the latter being connected to the galvanometer by other leads. If a short circuit key were used for the instrument, the shunt leads would be joined to the two terminals of that key, and where the plug commutator is used, as in the figure, these leads might more suitably be brought to the terminals A and A′. As long as they are connected to two points, which are also joined to the terminals of the galvanometer coils, it does not matter whether they are kept there or taken directly to the galvanometer itself. It is merely a case of leads in two sections instead of one. Some galvanometers have shunts made specially for them, in which case they are coils of a certain resistance, each being a proportional part of the galvanometer's resistance. They are usually marked $\frac{1}{9}$, $\frac{1}{99}$, $\frac{1}{999}$; when thus arranged they shunt off respectively $\frac{1}{10}$, $\frac{1}{100}$, $\frac{1}{1000}$ of the current passing in the circuit from the galvanometer, the deflection being, therefore, multiplied by 10, 100, or 1,000, as the case may be. We do not stop to show how these values are ascertained. The text books explain the rules for calculating shunt power. When the shunt is an ordinary resistance box, of course any resistance can be chosen and utilised by unplugging as much as we require.

We proceed now to consider the test for capacity taken with the connections as represented in Fig. 16. We will first test the condenser, and thus get a value by which to determine the capacity of the cable. We are not going to test the capacity of the condenser. We know what that is, it is $\frac{1}{2}$ or $\frac{1}{3}$rd of a microfarad, as the case may be; but we are to see what that capacity will give us. In other words, how many divisions on the scale will that known quantity or accumulation of electricity compel the galvanometer to show by discharging it through the coils. Let the condenser be $\frac{1}{2}$ microfarad. We choose this value because it makes the test somewwhat simpler, and the $\frac{1}{2}$ is as commonly used as the $\frac{1}{3}$ microfarad. One of the poles is to be connected to earth by a piece of insulated wire. There are several terminals in different parts of the room, or several wires each of which is connected with some good "earth," generally a large copper plate, buried in a damp spot, which suffices for as many earth terminals as may be joined to it. Next, the other condenser pole will be joined up to the quadrant B of the four-way piece (Fig. 16), connection with which to the key is effected by the plugs and the short lead to L, and the plug in the battery commutator will be removed to the hole for joining 10 cells. Now, if we were to charge this condenser and then discharge it through the galvanometer without having any shunt in circuit we should cause the mirror to swing so far that the spot would pass far beyond the end of the scale—we should get no readable deflection. The answer to the question, "What resistance ought our shunt to have?" depends on the resist-

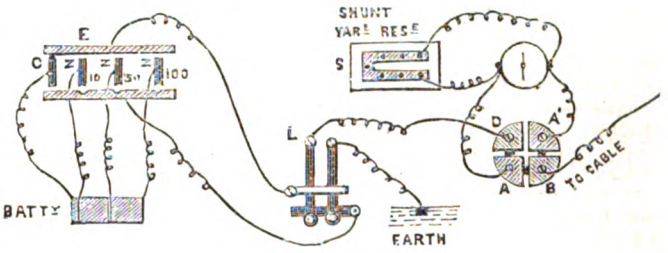

FIG. 16.

ance of the galvanometer used. The learner would most likely be saved all difficulty on this point, since he would be told what shunt to use, it being usual to note the amount of resistance necessary for the galvanometer which is to be employed (that is, with reference to the condenser). Supposing, however, that he were obliged to find it out for himself, it may be useful presently to show him how to set about it. For the moment we must point out how the discharge is effected. The operator will see that no charge can come from the battery as long as the key pieces L and L′ are up against the bar, because one pole is to earth and the other is insulated, but when (after removing the condenser plug) the left hand key L is pressed down (Fig. 16) a charge will pass out at L through D and by A and B to the condenser (which is supposed to be in the place of the cable in the figure), and if the plug remained inserted between A and B, the galvanometer, as before shown, would be short circuited, the charge going straight across to the condenser. Leaving this so for the moment, let us suppose we suddenly release the key, which we had kept pressed down; it will fly up against the upper bar and the charge will rush back from the condenser and pass to earth by coming back to L and by this bar to the terminal connected to earth, taking exactly the reverse of the course followed in charging. The condenser has been discharged, but there is no deflection on the scale. Of course, in practice no one would purposely bring this about, but if it were done, say, by accident, it would be proper to insert the condenser plug for a moment to cause any residual charge in the one side to be dissipated or destroyed by recombination with the opposite kind of electricity in the other side. The galvanometer short-circuit plug must necessarily be removed to allow of a deflection, and then when the

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key is sprung back the discharge goes by A^1 through the galvanometer, and shunt if any, to A, and finally to earth by the key. When a shunt is used, as stated to be necessary, it acts as a branch circuit, and if judiciously chosen, gives a good deflection. After noting the value (the number of divisions passed over by the spot), the condenser will be removed, and the cable joined up in its place. This may be done by plugging in the large commutator described in No. I., and thus connecting one end of either the core or cable lead to a terminal near the instrument, which terminal has a short lead to the small galvanometer commutator; or, if there should be no large commutator, there will be a lead to which the cable would be joined, and the end of this may be connected to the terminal. In effect, the arrangement is practically as shown in Fig. 16. Remembering that it was necessary to put one pole of the condenser to earth for testing, the learner may not, perhaps, see how to satisfy the condition in the case of the cable. But a moment's consideration of some foregoing remarks in No. VI. will remind him that the cable has always one pole to earth through its outer sheathing, though it is only when concerned with electricity in a *static* form, or, as an accumulated charge, that we regard it as having opposite poles. With *current* electricity the copper interior is simply a conductor, or may be so considered. At any rate the two cases may be looked at as practically distinct.

Continuing the test, supposing the shunt to have been properly chosen, and its required resistance unplugged in the shunt box, the left-hand key will be pressed down as before, and, after 15 seconds or so, the short circuit plug between A and B (Fig. 16) will be taken out, and, 15 seconds later, the key will be suddenly released, the operator keeping his eye on the scale and marking the number of the division at which the spot stops before flying back, which, of course, it must do since the discharge had caused it to swing from its position of rest to which it naturally returns. This deflection being noted, the determination of the cable's capacity is easy enough. As a discharge from a condenser of $\frac{1}{2}$ microfarad capacity with a shunt of a certain resistance is found to be so many divisions, say 350, what is the capacity of a cable (also a condenser) whose discharge with a certain shunt gives us 340 divisions? Or, in rule of three shape:—As 350 × the multiplying power of the shunt : 340 × the multiplying power of *its* shunt :: $\frac{1}{2}$ microfarad : the number of $\frac{1}{2}$ microfarads of the cables; and as the condenser is $\frac{1}{2}$ microfarad, or m.f.d., one m.f.d. would have given twice the deflection, therefore the question may be put thus:—As twice the condenser's deflection value : to that of the cable :: 1 m.f.d. to the capacity of the latter.

A word or two about the choice of a shunt is appropriate at this point; the learner will find it of assistance in such a case as where he has no idea what resistance he ought to use, and no information by comparison with other cables or condensers. The spot of light is, let us say, in the centre of the scale at zero. The discharge being measured by the swing, and the object being to compare the one deflection with the other, it is advisable to have as large a deflection as possible within the limits of the scale. It must be noted that the spot flies over the divisions pretty sharply, and practice is required to mark correctly the line representing the true deflection. The beginner seeking to find the proper shunt should begin with trying a very small one, the smaller the better; for he will understand that the smaller the resistance of the shunt is the greater is the proportion of the charge shunted off from the galvanometer, and that which passes through the galvanometer coils is alone concerned in producing the deflection. Finding, after charging and discharging with the shunt he tried as a first attempt, that the deflection is too small, he should unplug more resistance and try again until he finds the discharge gives him, say, 350. It is proper to insert the condenser plug for a moment after each operation, for the reason given above, namely, that its plates may be thoroughly discharged.

It will be seen that when, in the course of the test, the short circuit plug is taken out from between A and B the *charge* which went straight to the cable now goes also through the galvanometer, but no deflection is caused until the *discharge* takes place, and this may appear strange. If the learner did not take notice of this just now, the point would most probably occur to him later on, and the explanation is appropriate to the immediate subject. A glance at the connections in Fig. 16 will, in the first place, show that the deflection (say to the *right* on the scale) is caused by the discharge from the cable going through A′ and round the galvanometer coils, whilst the *charge* goes by A in the opposite direction, so that any deflection from the latter could only be on the *left* side of the scale; but even on this side no deflection is seen. A second point to be noticed is that a small battery power only is employed, and then the shunt relieves the galvanometer of so great a portion of the charge which would otherwise pass through it that the impulse in this direction is practically reduced to *nil*.

We will now take this test with the connections as seen in Fig. 17. It is to be observed that the shaded part in the trigger key is intended to represent *conducting* portion, and that left white is insulating. Here the galvanometer has no concern with the *charge*, but is simply affected by the *discharge*. It would be simpler in some respects to dispense with the galvanometer commutator or four-way piece, but then we could not bring the deflection at will on either side of the scale when using the same current. With the commutator as here shown we can reverse the deflection, bringing it either to the right or left. Further, we can make the opposite currents deflect the mirror always on the same side by merely shifting the plugs; and this is often necessary, as when we wish to see if a positive current gives the same discharge as a negative current. For though this might be done by observing the deflections on both sides of the centre or zero, it is better to have both on the same side,

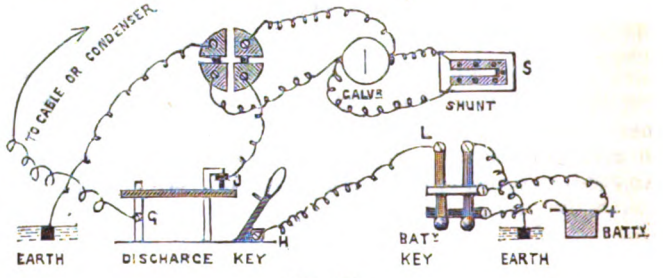

Fig. 17.

since the suspension of the mirror may cause a current to show a trifling difference in the swing on opposite sides. The spot might give 300 when swinging to the right, and 298, perhaps, if swung to the left.

The condenser will first be joined up, as it was in the other case (10 cells being plugged in the battery commutator); the leads from the battery are in the figure taken directly to the key, but the commutator is supposed to intervene. The battery key will be depressed and clamped down. This may remain so until the test is finished, because no charge will result until the trigger key connects it with the condenser or cable. This latter key (that is, the handle) is now to be pushed on to the bar, which is thus pressed down a little and disconnected from the point J. The charge enters the condenser, and after, say 20 or 30 seconds, the trigger is drawn back and the bar, striking against J, causes the discharge from the condenser to pass through the galvanometer and shunt, and by the commutator to earth. The deflection is noted, and the cable substituted for the condenser, and the same process is repeated with it. The battery key should always be carefully released after the test. It should never be left down when not in use.

This test for capacity by discharge is for general purposes sufficiently correct, and very handy in relation to its simplicity, but it does not give absolutely true results; and further on we shall explain the reasons for preferring the test by balance which will come before us in a later number.

The learner will remember the actual state of arrangement of the cable and core as described in an early paper, and shown in No. V., Fig. 9. He will see that both core and cable end is insulated at the large commutator, as long as no plug connects the bar to anything else, and though in the

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figure the connections are for the electrometer, there are other bars crossing the core and cable bars, and by plugging in at the proper place connection would be made for the discharge test instead of the electrometer. He could, therefore, test for capacity from either end by plugging in at the bar to which the core lead is joined, and leaving the opposite or cable bar free, or *vice versâ*. The discharge should be exactly the same either way.

We now take leave of this test for the present, and shall turn to the interesting subject of insulation resistance, and how it is measured.

STUDENTS' COLUMNS.

A small space will be devoted to the discussion of examinations, and examination questions. We think students should send us specimen solutions to the various examination questions, that we might select such answers for publication as seemed to us to come nearest to the answer required by the examiners. There are certain classes of questions which we cannot discuss, except in the manner indicated. We cannot in these columns undertake to describe or compare machines, though we might give John Brown's answer to such a question. We cannot select one machine for description out of a dozen. Answers requiring this must be the work of individual readers, and not ours. Certain questions are set by examiners with a special object, such, for example, as to test the observing powers of the candidate, or his generalising power. It may interest a few to have answers to such questions—to us it would mean a waste of space, and confer no real benefit whatever. Many of the answers will be framed more to give information than to give a specimen answer. We do not seek to aid a certain few men to pass an examination, but to aid the many students to give a definiteness and concreteness to their knowledge. Answer questions, not to pass examinations, but to be sure you know the subject, not resting satisfied with the mere idea that you know it:—

City and Guilds Institute.

Examination Papers, 1882.

1. Explain fully why at the present day it is more economical to light large rooms with the electric light than with gas, and why this was not the case some few years back?

Ans. A few years ago (1) the current required for electric lamps had to be obtained by the consumption of zinc in the ordinary voltaic batteries. The cost from this alone rendered the electric light far less economical than that of gas; (2) the electric lamps were more cumbrous—and almost entirely of the "arc" type—than similar lamps of the present day; (3) the discovery of Faraday, which led to the invention of magneto and dynamo machines, has also led to an immense cheapening of the electric current required for electric lamps, hence the improvements in lamps and machines enable us now to compete successfully with gas in lighting large rooms, and especially so where using "arc" lamps.

2. What is the principle of a dynamo machine? Explain in detail the construction of the dynamo with which you are best acquainted, describing the nature of the material (soft iron, cast iron, or steel, &c.) employed in each part, and giving full sketches illustrating the mode of winding the coils, and the size and shape of each part of the machine, as well as the reasons, as far as you know them, for the method of manufacture employed.

Ans. Induction. Professor Adams (Cantor Lectures) says:—"The fundamental principles which underlie all magneto-electric machines are the four great principles discovered by Oersted in 1819, by Ampère and Arago in 1820, and by Faraday in 1831. In 1819, Oersted discovered the action of a current of electricity on a magnet. In 1820, Ampère discovered the action of magnets and currents on currents of electricity in their neighbourhood, and in the same year Arago showed that currents of electricity produced magnetisation, thus laying the foundation of electromagetism; and in 1831 Faraday showed that induced currents were produced by the motion of magnets. All machines for the conversion of work into electricity are founded on Faraday's great discovery of the induced current, derived from the relative motion of a magnet and a coil of wire."

[The answer to the latter portion of this question we cannot give, inasmuch as we must, by giving it, necessarily describe some particular machine, and, however unbiased we might be, many would regard such description as showing we had a leaning in favour of some one machine, which would be an inference altogether at variance with the true state of the case, which is that we view all machines in the same light, and have no preference.—Ed. *E.*]

3. Explain fully, with sketches, how dynamo machines of the Brush type differ from those of the Gramme. What are the relative advantages and disadvantages of direct and alternate current dynamos?

Ans. The answer to the first part of this question can be obtained by consulting any modern book on electric lighting, such as those of Dredge, Higgs, Hospitalier. With direct current machines, almost any lamp (arc or incandescent) may be used, secondary batteries may be charged, power transmitted, and a second machine is not generally used as an exciter. It has the disadvantage of requiring brushes, and hence more and more loss with currents of great intensity. With alternate current machines an exciter is generally used. These machines can be employed with only certain arc lamps, but incandescent lamps are *said* to have a longer life when they are used. Alternate current machines are not adapted for transmitting power, nor charging secondary batteries, nor for many electro-chemical and metallurgical operations. They have the advantage that any number of the coils may be connected in series, or in multiple arc. Each set of coils may be connected to an external circuit. There seems to be no limit to the intensity of current which may be obtained except such as is imposed by the properties of the materials used in construction. Alternate current machines are more liable to loss by heat developed where it is not wanted than are direct current machines, &c.

[We must say that the word "relative" in the question renders it quite incomprehensible to us, and the above must therefore be taken for what it is worth.]

5. How many feet (about) of copper wire $\frac{1}{20}$th of an inch in diameter would have one ohm resistance at 60°F.? About how much per cent. is the resistance of copper wire altered by an increase of 15°F. in the temperature, and is the resistance increased or decreased?

Ans. About 230 or 240 feet.

If the student is to show how the number of feet is obtained he may work thus:—

1 mile (1,760 yards) copper wire has $R = \frac{54892}{d^2}$, where d is expressed in mils., *i.e.*, $\frac{1}{1000}$th of an inch.

Now $\frac{1}{20}$ inch = 50 mils.

∴ Resistance of 1 mile of wire 50 mils. in diameter is found

$$R = \frac{54892}{(50)^2} = \frac{54892}{2500} = \frac{219568}{10000} = 21{\cdot}9568.$$

$$\therefore \frac{1760 \times 3}{21{\cdot}9568} = \text{number of feet per ohm} = 240 \text{ nearly.}$$

or

As the percentage increase resistance of Cu. wire per 1°F. is about ·21, say ·2, and 1 foot of hard-drawn Cu. wire 1 mil. diameter at 32°F. has R = 9·940 ohms—say, for simplicity, = 10 ohms,

∴ The number (x) feet of Cu. wire in 1 ohm of 50 mils. diameter

$$= \frac{10 \times x}{2500} = 1.$$

$x = 250$ = number of feet with R = 1 ohm at 32°F.,

60°F. − 32°F. = 28°F.,

and $28 \times {\cdot}2 = 5{\cdot}6$, which represents increased resistance per cent. for the 28°.

$$\therefore 250 - (2{\cdot}5)\,(5{\cdot}6) = R \text{ at } 60° = 250 - 14 = 236.$$

The resistance increases ·21 per cent. for a rise of temperature of 1°F.

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INTERNATIONAL CONFERENCE FOR THE PROTECTION OF SUBMARINE CABLES.

Introductory report, drawn up by the special committee, composed of MM. Dambach (Germany), Renault (France), Trevor (Great Britain), Velasco (Mexico),* Asser (Netherlands).

Before commenting briefly on the various proposals we submit for discussion to the Conference, we deem it right to state that our resolutions do not commit the Governments of the delegates present, but are intended only to facilitate the deliberations of the Conference. The general scope of our proposals may be thus summed up. We have endeavoured to show our utmost respect for the sovereignty and laws of the contracting States, and have suggested only such fresh enactments as appeared to us indispensable for the attainment of the desired end.

The high contracting parties being desirous of securing the maintenance of telegraphic communications by means of submarine cables have agreed on a convention to this effect, and have appointed:—

Clause I. "The present Convention applies outside territorial waters to all submarine cables legally laid between the territories of the high contracting parties."

The Convention applies only to cases outside territorial waters, for its object is precisely to regulate the common use of the high sea, which is the domain of no particular State. As for what occurs on the territory, or within the territorial waters, of any particular State, it is for that State to bring such case within the ambit of its regular sovereignty. As a rule submarine cables are protected by the existing laws of the various States against all interference at their landing stages, or within territorial waters. If by chance this were not the case in any State desirous of joining the Convention such State must, of course, make the necessary enactments; for, of course, one cannot understand an act being punishable if committed on the high seas, and yet unpunishable if committed on the territory, or within the territorial waters of such a State.

By the expression "all cables legally laid," we have desired to point out that there was no distinction to be drawn between State and private cables, that it was sufficient for them to have been regularly established.

But we have only in view the cables connecting contracting States, for this Convention is intended to benefit only those States who are signatories thereto, and not those States unwilling to incur the obligations it imposes on Governments and individuals.

Clause II. "The breaking or deteriorating of a submarine cable, when done wilfully or through culpable negligence, and having for result the interruption or impeding of telegraphic communication, is punishable, without prejudice to a civil action for damages."

This provision does not apply to breakages or deteriorations effected with the sole object of protecting life, or of securing the safety of a vessel, and after taking all necessary precautions for avoiding such breakages or deteriorations.

Paragraph first of this clause is worded in accordance with general usage in this respect. It has for its object two different sets of circumstances. The damage may have been done with even *malicious* intent, for the purpose of interrupting the telegraphic communication from some interested motive or other. This is the simplest case of all, and should admit of no hesitation, since the act concerned is both pernicious and prejudicial.

On the other hand, it may happen that the damage has not been perpetrated in the spirit suggested above, but is the result merely of negligence. Thus, an anchor or trawl may foul a cable. Well, with a little care, or, as an English judgment has it, "with ordinary seafaring skill," the anchor or trawl might be got clear without damaging the cable; whereas, on the contrary, the fishermen or sailors take no such precautions, but go roughly to work, and by their carelessness either break or injure the cable. Such negligence should therefore be punished.

We have deemed it best to confine ourselves to this general rule, and to leave it to the judges to determine in each case whether there has been culpable negligence, or whether, to borrow the words of an important official document (*vide* Article 247 of Décret Français, 4th November, 1879, concerning rules for preventing collisions at sea), "the precautions enjoined by ordinary seafaring experience, and the particular circumstances under which the vessel was at the time, have been complied with."

Strictly speaking, this clause might have been limited to its first paragraph. For, of course, if the master of a ship or smack cuts or damages a cable solely for the purpose of saving his life or his craft, he cannot be held to have been guilty of fraudulent intent or culpable negligence. With a view, however, of precluding all misunderstanding and equivocation on this head, as also of preventing a scare amongst seafaring men from the general terms of the first paragraph, we have deemed it needful to use extra explicitness, and tack on this outrider.

Clause III. "The high contracting parties hereto mutually undertake to prevent as much as possible the various submarine cables from crossing one another, or being in too close proximity to one another."

The idea conveyed in this clause was adopted by the Conference in its fifth sitting (*vide* Minutes, page 17). The committee has only applied itself to the elimination of such terms as had given rise to disagreements, notably the word "juxtaposé," and they venture to hope the wording they have adopted will satisfy the wishes of the Conference.

The proposed clause expresses a general undertaking on the part of the several Governments without specifying the means for carrying it out, the said Governments being thus at liberty to dictate their terms to the parties soliciting concessions without troubling themselves about what course of action the Government at the other end of the cable may think fit to pursue, or, on the contrary, to come to an understanding with him.

Clause IV. "The owner of a cable which, when being laid or repaired, breaks or injures another cable, shall bear the cost of the repairs necessitated by such breakage or injury, without prejudice, if occasion calls for it, of Clause II."

The principle embodied in this clause was recognised by the Conference in its fifth sitting (*vide* Minutes, page 17).

The concluding words of this Clause IV. are intended to show that the obligation of indemnification is based on the material injury done, and not on the indirect injury resulting from the interruption of telegraphic communication.

Clause V. "The vessels employed in the laying or repairing of submarine cables must observe the rules as to signals which are or shall be adopted in common accord by the high contracting parties with a view to prevent collisions.

"When a vessel engaged in repairing a cable has thus signalled, the other ships and craft which see or can see said signals must either draw off, or keep at a distance of at least one nautical mile from said vessel, so as not to bore her in her movements.

"Fishing boats must keep their nets and fishing gear the same distance away from said repairing vessel.

"All ships or craft when thus signalled by said repairing ship shall have a delay of twenty-four hours at the outside accorded them, during which term no obstacle shall be placed in the way of their movements.

"The telegraph repairing vessel shall complete its operations with all possible celerity."

This clause was drafted in consonance with the information supplied by the technical delegates. We have, in the wording of its stipulations, endeavoured to conciliate the interests of the telegraph repairing ships with those of other ships, and specially of fisher boats.

It was generally agreed that it was not necessary to insist on any special regulations for the guidance of ships engaged in laying cables, but that such regulations were necessary for the guidance of ships which, engaged in repairing broken or injured cables, are compelled to remain more or less in the one spot, and have not the choice of weather for doing their work. It is, therefore, to the general interest that they shall not be interfered with in their work, so that they may get through it with all possible celerity, and that telegraphic communications may be restored. It is equally to the interest of the cable owners themselves that the repairs be promptly executed, and this interest is in itself a guarantee that the inconvenience thus occasioned to merchant ships or fisher boats will not be continued longer than necessary.

Clause VI. "All craft seeing, or capable of seeing, the buoys used for indicating the position of cables shifted or broken shall keep at a quarter of a mile off at least.

"Fishermen shall keep their nets and fishing gear and appliances at an equal distance."

Article VII. "The owners of ship or craft able to prove they have sacrificed an anchor or net so as not to damage a submarine cable shall be indemnified by the owner of said cable.

"In order to be able to lay claim to such indemnity, a detailed report must be drawn up of the accident, as soon after its occurrence as possible, and attested by the crew. At at events the master of the vessel concerned must always, within twenty-four hours after reaching port of destination or call, lodge his declaration with the officials concerned. These officials shall notify the fact to the consuls or consular agents of the country to which the owner of the cable belongs."

Clause VIII. "The tribunals competent to take cognizance of infractions of this Convention are those of the nation to which the delinquent ship or craft belongs, subject to the subsidiary application of the general rules of national penal competency springing out of the particular laws of States or international treaties."

The essential provision of this clause seems to be qualified in the first place by the general principles of penal law, according to which the tribunal naturally competent to try an infraction is the tribunal of the country wherein the infraction has been committed. On the high seas vessels may be considered as forming part of the territory of the State whose flag they fly. It is, therefore, consonant with logic that the tribunals of such State should adjudicate on the infractions committed on board such vessels, whatever may be the nationality of the delinquents themselves.

This stipulation is specially commendable from the fact of its being analogous to one contained in the Hague Fishery Convention (Clause 36). A member of the committee, however, has suggested drafting the opening of the clause thus:—

"The tribunals competent to take cognizance of infractions of this Convention are those of the State the least removed from the spot where the delinquency was committed."

We will now proceed to explain the meaning of the proviso at the end of this eighth clause. It alludes to the particular laws of States and to international treaties, and calls for a word of explanation on these two points.

1. It may happen that the tribunals of a State which are not competent according to the preceding rule may be so by virtue of another principle. Let us, then, suppose a German or Frenchman committing such an infraction of the Convention on board a British vessel. If tried by the British Court there is an end of the matter. But this German or Frenchman may return to his own country without having been tried in England. Is he, or are they, to evade all punishment because his or their native country will not surrender him or them to England? This is unnecessary, and there is no reason for discarding the application of common law, which allows a State to demand an account of its subjects of their doings abroad. The Frenchman or the German can be prosecuted in their own country, by virtue of common law (German Penal Code, Clause ——; French Penal Code, Clause 5). This provision should, therefore, meet with the concurrence of all the Powers, for it is for the benefit of their sovereignty.

2. According to certain treaties, the subjects of one State are exempted from the jurisdiction of another State, as subject only to the jurisdiction of their own country. The principle laid down in the opening of the clause if applied singly would lead to inadmissible results.

Clause IX. "The prosecution for delinquencies and contraventions described in this Convention shall be conducted in the name of or by the State."

This is a reiteration of Clause 34 of the Hague Fishery Convention.

Mr. Trevor, however, has recorded certain provisos on this point.

Clause X. "The infraction of this Convention can be verified by all modes of proof permitted by the laws of the country wherein the Court appealed to sits. Moreover, the commanding officers of men of war, or of vessels specially commissioned for such purpose by one of the high contracting parties, whatever be the nationality of the craft whereon the infraction has been committed, may report on the proceedings.

"These reports shall be drawn up in accordance with the formalities, and in the language in use in the country to which the officer thus reporting

* Unforeseen circumstances having necessitated Mr. Asser's recall from Paris, his place during several sittings was taken by Mr. Jansen.

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belongs, and shall have the same weight in the country they may be appealed to as if they emanated from the competent authorities of that country."

For the proof of the infractions, the clause refers to the laws of the country wherein they are tried, that is the common law.

The right of reporting was adopted by analogy by the Hague Fishery Convention (Clause 28).

The second paragraph is a reiteration of Clause XXXI., Paragraph I., of the same Convention.

Clause II. "The procedure and the judgment of the contraventions of the provisions of this Convention shall always be carried out as summarily as the laws and regulations in force permit."

This clause is only a reiteration of Clause 37 of the Hague Fishery Convention.

Article XII. "The high contracting parties hereto undertake to adopt, or to propose to their respective Legislatures, the measures requisite for carrying out this Convention, and notably for punishing either with imprisonment or fine, or both, all contraventions of the provisions of Clauses 2, 5, and 6."

Clause XIII. "The high contracting parties hereto shall communicate the laws which may already have been passed, or may subsequently be passed, in their respective States relative to the object of this Convention."

Clause XIV. "This Convention shall be ratified. The ratification shall be interchanged in Paris within the shortest delay possible."

Clause XV. "This Convention shall be in force from the day the high contracting parties shall agree on.

"It shall remain in force —— years from said date, and in the event of any of the high contracting parties failing to notify twelve months before the expiration of said term of —— years its intention of withdrawing from this Convention, it shall continue in force another year, and so on from year to year.

"In the event of any of the high contracting parties renouncing this Convention, such renunciation would affect only the high contracting party thus renouncing."

SOCIETY OF ARTS.

On Wednesday, Nov. 15, the President, Dr. C. W. Siemens, F.R.S., gave his inaugural address, which referred principally to electric lighting. Dr. Siemens said: Having received the honour of being elected Chairman of the Council of the Society of Arts for the ensuing year, the duty devolves upon me of opening the coming session with some introductory remarks.

* * * * *

Amongst the practical questions that now chiefly occupy public attention are those of electric lighting, and of the transmission of force by electricity. These together form a subject which has occupied my attention and that of my brothers for a great number of years, and upon which I may consequently be expected to dwell on the present occasion, considering that at Southampton I could deal only with some purely scientific considerations involved in this important subject. I need hardly remind you that electric lighting, viewed as a physical experiment, has been known to us since the early part of the present century, and that many attempts have from time to time been made to promote its application. Two principal difficulties have stood in the way of its practical introduction, viz., the great cost of producing an electric current so long as chemical means had to be resorted to, and the mechanical difficulty of constructing electric lamps capable of sustaining with steadiness prolonged effects. The dynamo-machine, which enables us to convert mechanical into electrical force, purely and simply, has very effectually disposed of the former difficulty, inasmuch as a properly conceived and well constructed machine of this character converts more than 90 per cent. of the mechanical force imparted to it into electricity, 90 per cent. again of which may be re-converted into mechanical force at a moderate distance. The margin of loss, therefore, does not exceed 20 per cent., excluding purely mechanical losses, and this is quite capable of being further reduced to some extent by improved modes of construction; but it results from these figures that no great step in advance can be looked for in this direction. The dynamo-machine presents the great advantage of simplicity over steam or other power-transmitting engines; it has but one working part, namely, a shaft which, revolving in a pair of bearings, carries a coil or coils of wire admitting of perfect balancing. Frictional resistance is thus reduced to an absolute minimum, and no allowance has to be made for loss by condensation, or badly fitting pistons, stuffing boxes, or valves, or for the jerking action due to oscillating weights. The materials composing the machine, namely, soft iron and copper wire, undergo no deterioration or change by continuous working, and the depreciation of value is therefore a minimum, except where currents of exceptionally high potential are used, which appear to render the copper wire brittle. The essential points to be attended to in the conception of the dynamo-machine are the prevention of induced currents in the iron, and the placing of the wire in such position as to make the whole of it effective for the production of outward current. These principles, which have been clearly established by the labours of comparatively few workers in applied science, admit of being carried out in an almost infinite variety of constructive forms, for each of which may be claimed some real or imaginary merits regarding questions of convenience or cost of production. For many years after the principles involved in the construction of dynamo-machines had been made known, little general interest was manifested in their favour, and few were the forms of construction offered for public use. The essential features involved in the dynamo-machine, the Siemens armature (1856), the Pacinotti ring (1861), and the self-exciting principle (1867), were published by their authors for the pure scientific interest attached to them, without being made subject matter of letters patent, which circumstance appears to have had the contrary effect of what might have been expected, in that it has retarded the introduction of this class of electrical machine, because no person or firm had a sufficient commercial interest to undertake the large expenditure which must necessarily be incurred in reducing a first conception into a practical shape. Great credit is due to Monsieur Gramme for taking the initiative in the practical introduction of dynamo-machines embodying those principles, but when, five years ago, I ventured to predict for the dynamo-electric current a great practical future, as a means of transmitting power to a distance, those views were still looked upon as more or less chimerical. A few striking examples of what could be practically effected by the dynamo-electric current, such as the illumination of the Place de l'Opera, Paris, the occasional exhibition of powerful arc lights, and their adoption for military and lighthouse purposes, but especially the gradual accomplishment of the much desired lamp by incandescence in vacuum, gave rise to a somewhat sudden reversion of public feeling; and you may remember the scare at the Stock Exchange, affecting the value of gas shares, which ensued in 1878, when the accomplishment of the sub-division of the electric light by incandescent wire was first announced, somewhat prematurely, through the Atlantic cable.

From this time forward electric lighting has been attracting more and more public attention, until the brilliant displays at the exhibition of Paris, and at the Crystal Palace last year, served to excite public interest to an extraordinary degree. New companies for the purpose of introducing electric light and power have been announced almost daily whose claims to public attention as investments were based in some cases upon only very slight modifications of well-known forms of dynamo-machines, of arc regulators, or of incandescent carbon lights, the merits of which rested rather upon anticipations than upon any scientific or practical proof. These arrangements were supposed to be of such superlative merit that gas and other illuminants must soon be matters simply of history, and hence arose great speculative excitement. It should be borne in mind, however, that any great technical advance is necessarily the work of time and serious labour, and that when accomplished, it is generally found that so far from injuring existing industries, it calls additional ones into existence, to supply new demands, and thus gives rise to an increase in the sum total of our resources. It is, therefore, reasonable to expect that side by side with the introduction of the new illuminant, gas lighting will go on improving and extending, although the advantages of electric light for many applications, such as the lighting of public halls and warehouses, of our drawing rooms and dining rooms, our passenger steamers, our docks and harbours, are so evident, that its advent may be looked upon as a matter of certainty. Our legislature has not been slow in recognising the importance of the new illuminant. In 1879 a Select Committee of the House of Commons instituted a careful inquiry into its nature and probable cost, with a view to legislation, and the conclusions at which they arrived were, I consider, the best that could have been laid down. They advised that applications should be encouraged tentatively by the granting of permissive Bills, and this policy has given rise to the Electric Lighting Bill, 1882, promoted by Mr. Chamberlain, the President of the Board of Trade, regarding which much controversy has arisen. It could, indeed, hardly be expected that any act of legislation upon this subject could give universal satisfaction, because while there are many believers in gas who would gladly oppose any measure likely to favour the progress of the rival illuminant, and others who wish to see it monopolised, either by local authorities or by large financial corporations, there are others again who would throw the doors open so as to enable almost all comers to interfere with the public thoroughfares, for the establishment of conducting wires, without public let or hindrance. The law as now established takes, I consider, a medium course between these diverging opinions, and, if properly interpreted, will protect, I believe, all legitimate interests, without impeding the healthy growth of establishments for the distribution of electric energy for lighting and for the transmission of power. Any firm or lighting company may, by application to the local authorities, obtain leave to place electric conductors below public thoroughfares, subject to such conditions as may be mutually agreed upon, the term of such license being limited to seven years; or an application may be made to the Board of Trade for a provisional order to the same effect, which, when sanctioned by Parliament, secures a right of occupation for twenty-one years. The license offers the advantage of cheapness, and may be regarded as a purely tentative measure, to enable the firm or company to prove the value of their plant. If this is fairly established, the license would in all probability be affirmed, either by an engagement for its prolongation from time to time, or by a provisional order which would, in that case, be obtained by joint application of the contractor and the local authority. At the time of expiration of the provisional order, pre-emption of purchase is accorded to the local authority, against which it has been objected with much force by so competent an authority as Sir Frederick Bramwell that the conditions of purchase laid down are not such as fairly to remunerate the contracting companies for their expenditure and risk, and that the power of purchase would inevitably induce the parochial bodies to become mere trading associations. But while admitting the undesirability of such a consummation, I cannot help thinking that it was necessary to put some term to contracts entered into with speculative bodies at a time when the true value of electric energy, and the best conditions under which it should be applied, are still very imperfectly understood. The supply of electric energy, particularly in its application to transmission of power, is a matter simply of commercial demand and supply, which need not partake of the character of a large monopoly similar to gas and water supply, and which may therefore be safely left in the hands of individuals, or of local associations, subject to a certain control for the protection of public interests. At the termination of the period of the provisional order, the contract may be renewed upon such terms and conditions as may at that time appear just and reasonable to Parliament, under whose authority the Board of Trade will be empowered to effect such renewal. Complaints appear almost daily in the public papers to the effect that townships refuse their assent to applications by electric light companies for provisional orders; but it may be surmised that many of these applications are of a more or less speculative character, the object being to secure monopolies for eventual use or sale, under which circumstances the authorities are clearly justified in withholding their assent, and no licenses or provisional orders should, indeed, be granted, I consider, unless the applicants can give assurance of being able and willing to carry out the work within a reasonable time. But there are technical questions involved which are not yet sufficiently well understood to admit of immediate operations upon a large scale. Attention has been very properly called to the great divergence in the opinions expressed by scientific men regarding the area that each lighting district should comprise, the capital required to light such an area, and the amount of electric tension that should be allowed in the conductors. In the case of gas supply the works are necessarily situated in the

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outskirts of the town, on account of the nuisance this manufacture occasions to the immediate neighbourhood: and, therefore, gas supply must range over a large area. It would be possible, no doubt, to deal with electricity on a similar basis, to establish electrical mains in the shape of copper rods of great thickness, with branches diverging from them in all directions; but the question to be considered is, whether such an imitative course is desirable on account either of relative expense or of facility of working. My own opinion, based upon considerable practical experience and thought devoted to the subject, is decidedly adverse to such a plan. In my evidence before the Parliamentary Committee I limited the desirable area of an electric district in densely populated towns to a quarter of a square mile, and estimated the cost of the necessary establishment of engines, dynamo machines, and conductors at £100,000, while other witnesses held that areas from one to four square miles could be worked advantageously from one centre, and at a cost not exceeding materially the figure I had given. These discrepancies do not necessarily imply wide differences in the estimated cost of each machine or electric light, inasmuch as such estimates are necessarily based upon various assumptions regarding the number of houses and of public buildings comprised in such a district, and the amount of light to be apportioned to each, but I still maintain my preference for small districts. By way of illustration, let us take the parish of St. James's, near at hand, a district not more densely populated than other equal areas within the metropolis, although comprising, perhaps, a greater number of public buildings. Its population, according to the preliminary report of the census taken on the 4th April, 1881, was 29,865, it contains 3,018 inhabited houses, and its area is 784,000 square yards, or slightly above a quarter of a square mile. To light a comfortable house of moderate dimensions in all its parts, to the exclusion of gas, oil, or candles, would require about 100 incandescent lights of from 15 to 18 candle-power each, that being, for instance, the number of Swan lights employed by Sir William Thomson in lighting his house at Glasgow University. Eleven horse-power would be required to excite this number of incandescence lights, and at this rate the parish of St. James's would require 3,018 × 11 = 33,200 horse-power to work it. It may be fairly objected, however, that there are many houses in the parish much below the standard here referred to, but, on the other hand, there are 600 of them with shops on the ground floor, involving larger requirements. Nor does this estimate provide for the large consumption of electric energy that would take place in lighting the 11 churches, 18 club houses, 9 concert halls, 3 theatres, besides numerous hotels, restaurants, and lecture halls. A theatre of moderate dimensions, such as the Savoy Theatre, has been proved by experience to require 1,200 incandescence lights, representing an expenditure of 133 horse-power; and about one-half that power would have to be set aside for each of the other public buildings here mentioned, constituting an agregate of 2,926 horse-power; nor does this general estimate comprise street lighting, and to light the six and a-half miles of principal streets of the parish with electric light would require, per mile, 35 arc lights of 350 candle-power each, or a total of 227 lights. This, taken at the rate of 0·8 horse-power per light, represents a further requirement of 182 horse-power, making a total of 3,108 horse-power, for purposes independent of house lighting, being equivalent to one horse-power per inhabited house, and bringing the total requirements up to 109 lights = 12 horse-power per house. I do not, however, agree with those who expect that gas lighting will be entirely superseded, but have, on the contrary, always maintained that the electric light, while possessing great and peculiar advantages for lighting our principal rooms, halls, warehouses, &c., owing to its brilliancy, and more particularly to its non-interference with the healthful condition of the atmosphere, will leave ample room for the development of the former, which is susceptible of great improvement, and is likely to hold its own for the ordinary lighting up of our streets and dwellings. Assuming, therefore, that the bulk of domestic lighting remains to the gas companies, and that the electric light is introduced into private houses, only at the rate of, say, 12 incandescence lights per house, the parish of St. James's would have to be provided with electric energy sufficient to work (9 + 12) 3,018 = 63,378 lights = 7,042 horse-power effective; this is equal to about one-fourth the total lighting power required, taking into account that the total number of lights that have to be provided for a house are not all used at one and the same time. No allowance is made in this estimate for the transmission of power, which, in course of time, will form a very large application of electric energy; but considering that power will be required mostly in the day time, when light is not needed, a material increase in plant will not be necessary for that purpose.

In order to minimise the length and thickness of the electric conductor, it would be important to establish the source of power, as nearly as may be, in the centre of the parish, and the position that suggests itself to my mind is that of Golden-square. If the unoccupied area of this square, representing 2,500 square yards, was excavated to a depth of 25 feet, and then arched over so as to re-establish the present ground level, a suitable covered space would be provided for the boilers, engines, and dynamo machines, without causing obstruction or public annoyance, the only erection above the surface would be the chimney, which, if made monumental in form, might be placed in the centre of the square, and be combined with shafts for ventilating the subterranean chamber, care being taken of course to avoid smoke by insuring perfect combustion of the fuel used. The cost of such a chamber, of engine power, and of dynamo-machines, capable of converting that power into electric energy, I estimate at £140,000. To this expense would have to be added that of providing and laying the conductors, together with the switches, current regulators, and arrangements for testing the insulation of the wire. The cost and dimensions of the conductors would depend upon their length, and the electromotive force to be allowed. The latter would no doubt be limited by the authorities to the point at which contact of the two conductors with the human frame would not produce injurious effects, or say to 200 volts, except for street lighting, for which purpose a higher tension is admissible. In considering the proper size of conductor to be used in any given installation, two principal factors have to be taken into account; first, the charge for interest and depreciation on the original cost of a unit length of the conductor; and, secondly, the cost of the electrical energy lost through the resistance of a unit of length. The sum of these two, which may be regarded as the cost of conveyance of electricity, is clearly least, as Sir William Thomson pointed out some time ago, when the two components are equal. This, then, is the principle on which the size of a conductor should be determined. From the experience of large installations, I consider that electricity can, roughly speaking, be produced in London at a cost of about one shilling per 10,000 ampere volts or watts (746 watts being equal to 1 horse-power) for an hour. Hence, assuming that each set of four incandescence lamps in series (such as Swan's, but for which may be substituted a smaller number of higher resistance and higher luminosity) requires 200 volts electromotive force, and 60 watts for their efficient working, the total current required for 64,000 such lights is 19,200 amperes, and the cost of the electric energy lost by this current in passing through 1-100th of an ohm resistance is £16 per hour. The resistance of a copper bar one quarter of a mile in length, and one square inch in section, is very nearly 1-100th of an ohm, and the weight is about 2¼ ton. Assuming, then, the price of insulated copper conductor at £90 per ton, and the rate of interest and depreciation at 7½ per cent., the charge per hour of the above conductor, when used eight hours per day, is 1½d. Hence, following the principle I have stated above, the proper size of conductor to use for an installation of the magnitude I have supposed would be one 48·29 inches section, or a round rod eight inches diameter.

If the mean distance of the lamps from the station be assumed as 350 yards, the weight of copper used in the complete system of conductors would be nearly 168 tons, and its cost £15,120. To this must be added the cost of iron pipes, for carrying the conductors underground, and of testing boxes, and labour in placing them. Four pipes, of 10in. diameter each, would have to proceed in different directions from the central station, each containing sixteen separate conductors of 1in. diameter, and separately insulated, each of them supplying a sub-district of 1,000 lights. The total cost of establishing these conductors may be taken at £37,000, which brings up the total expenditure for central station and leads to £177,000. I assume the conductors to be placed underground, as I consider it quite inadmissible, both as regards permanency and public safety and convenience, to place them above ground, within the precincts of towns. With this expenditure, the parish of St. James's could be supplied with the electric light to the extent of 25 per cent. of the total illuminating power required. To provide a larger percentage of electric energy would increase the cost of establishment proportionately, and that of conductors, nearly in the square ratio of the increase of the district, unless the loss of energy by resistance is allowed to augment instead. It may surprise uninitiated persons to be told that to supply a single parish with electric energy necessitates copper conductors of a collective area equal to a rod of 8in. in diameter; and how, it may be asked, will it be possible under such conditions to transmit the energy of waterfalls to distances of twenty or thirty miles, as has been suggested. It must, indeed, be admitted that the transmission of electric energy of such potential (200 volts) as is admissible in private dwellings would involve conductors of impracticable dimensions, and, in order to transmit electrical energy to such distances, it is necessary to resort, in the first place, to an electric current of high tension. By increasing the tension from 200 to 1,200 volts the conductors may be reduced to one-sixth their area, and if we are content to lose a larger proportion of the energy obtained cheaply from a waterfall, we may effect a still greater reduction. A current of such high potential could not be introduced into houses for lighting purposes, but it could be passed through the coils of a secondary dynamo-machine, to give motion to another primary machine, producing currents of low potential to be distributed for general consumption. Or secondary batteries may be used to effect the conversion of currents of high into those of low potential, whichever means may be found the cheaper in first cost, in maintenance, and most economical of energy. It may be advisable to have several such relays of energy for great distances, the result of which would be a reduction of the size and cost of conductor at the expense of final effect, and the policy of the electrical engineer will, in such cases, have to be governed by the relative cost of the conductor, and of the power at its original source. If secondary batteries should become more permanent in their action than they are at the present time, they may be largely resorted to by consumers, to receive a charge of electrical energy during the day time, or the small hours of the night, when the central engine would otherwise be unemployed, and the advantage of resorting to these means will depend upon the relative first cost, and cost of working the secondary battery and the engine respectively. These questions are, however, outside the range of our present consideration. The large aggregate of dwellings comprising the metropolis of London covers about seventy square miles, thirty of which may be taken to consist of parks, squares, and sparsely inhabited areas, which are not to be considered for our present purpose. The remaining forty square miles could be divided into, say, 140 districts, slightly exceeding a quarter of a square mile on the average, but containing each fully 3,000 houses, and a population similar to that of St. James's. Assuming twenty of these districts to rank with the parish of St. James's (after deducting the 600 shops which I did not include in my estimate) as central districts, sixty to be residential districts, and sixty to be comparatively poor neighbourhoods, and estimating the illuminating power required for these three classes in the proportion of 1 to ⅔ to ⅓, we should find that the total capital expenditure for supplying the metropolis with electric energy to the extent of 25 per cent. of the total lighting requirements would be:—

20	×			177,000	=	£3,540,000
60	×	⅔	×	177,000	=	£7,080,000
60	×	⅓	×	177,000	=	£3,540,000
						£14,160,000

or say £14,000,000, without including lamps and internal fittings, and making an average capital expenditure of £100,000 per district. To extend the same system over the towns of Great Britain and Ireland would absorb a capital exceeding certainly £64,000,000, to which must be added £16,000,000 for lamps and internal fittings, making a total capital expenditure of £80,000,000. Some of us may live to see this realised, but to find such an amount of capital, and, what is more important, to find the manufacturing appliances to produce work representing this value of machinery and wire, must necessarily be the result of many years of technical development. If, therefore, we see that electric companies apply for provisional orders to supply electric energy, not only for every town throughout the country, but also for colonies, and for foreign parts, we are forced to the conclusion that their ambition is somewhat in excess of their power of performance; and that no provisional order should be granted except conditionally on the work being executed within a reasonable time, as without such a provision the powers granted may have the effect of retarding instead of advancing electric

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lighting, and of providing an undue encouragement to purely speculative operations. The extension of a district beyond the quarter of a square mile limit would necessitate an establishment of unwieldy dimensions, and the total cost of electric conductors per unit area would be materially increased; but independently of the consideration of cost, great public inconvenience would arise in consequence of the number and dimensions of the electric conductors, which could no longer be accommodated in narrow channels placed below the kerb stones, but would necessitate the construction of costly subways—veritable *cava electrica*. The amount of the working charges of an establishment comprising the parish of St. James's would depend on the number of working hours in the day, and on the price of fuel per ton. Assuming the 64,000 lights to incandesce for six hours a day, the price of coal to be 20s. a ton, and the consumption 2lb. per effective horse-power per hour, the annual charge under this head, taking eight hours' firing, would amount to about £18,300, to which would have to be added for wages, repairs, and sundries, about £6,000, for interest with depreciation at 7½ per cent. £13,300, and for general management say £3,400, making a total annual charge of £41,000, or at the rate of 12s. 9½d. per incandescence lamp per annum. To this has to be added the cost of renewal of lamps, which may be taken at 5s. per lamp of 16 candles, lasting 1,200 hours, or to 9s. per annum, making a total of 21s. 9½d. per lamp for a year. In comparing these results with the cost of gas lighting, we shall find that it takes five cubic feet of gas, in a good argand burner, to produce the same luminous effect as one incandescence light of 16 candle-power. In lighting such a burner every day, for six hours on the average, we obtain an annual gas consumption of 10,950 cubic feet, the value of which, taken at the rate of 2s. 8d. per 1,000, represents an annual charge of 29s., showing that electric light by incandescence, when carried out on a large scale, is decidedly cheaper than gas lighting at present prices, and with the ordinary gas burners.

On the other hand, the cost of establishing gas works and mains of a capacity equal to 64,000 argand burners would involve an expenditure not exceeding £80,000 as compared with £177,000 in the case of electricity; and it is thus shown that, although it is more costly to establish a given supply of illuminating power by electricity than gas, the former has the advantage as regards current cost of production.

It would not be safe, however, for the advocates of electric lighting to rely upon these figures as representing a permanent state of things. In calculating the cost of electric light, I have only allowed for depreciation and 5 per cent. interest upon capital expenditure, whereas gas companies are in the habit of dividing large dividends, and can afford to supply gas at a cheaper rate, by taking advantage of recent improvements in manufacturing operations, and of the ever-increasing value of their by-products, including tar, coke, and ammoniacal liquor. Burners, have, moreover, been recently devised by which the luminous effect for a given expenditure of gas can be nearly doubled by purely mechanical arrangements, and the brilliancy of the light can be greatly improved.

On the other hand, electric lighting also may certainly be cheapened by resorting, to a greater extent than has been assumed, to arc lighting, which, though less agreeable than the incandescence light for domestic purposes can be produced at less than half the cost, and deserves on that account the preference for street lighting, and for large halls, in combination with incandescence lights. Lamps by incandescence may be produced hereafter at a lower cost, and of a more enduring character.

The latter portion of the address referred principally to the question of heating by gas, Dr. Siemens stating that probably electricity would provide light, and gas would provide heat.

THE SOCIETY OF TELEGRAPH ENGINEERS.

The first meeting after the summer recess was held on Thursday, November 9, in the theatre of the Institution of Civil Engineers, Great George-street.

After the formal business of the meeting, a contribution by Colonel F. Bolton was announced. This gentleman has continued his list of electric light patents to a very recent date, and it will be seen that the introduction to this new list paid a well-deserved tribute to the management of the Society's library, in the hands of Mr. A. J. Frost. The introduction to Colonel Bolton's list was as follows:—

Some Further Historical Notes on the Electric Light, bringing the Subject up to the 30th September, 1882.

The paper on "Electric Lighting" which I had the honour to read before the Society in May, 1879, met with so favourable a reception, while, as I am assured, it has not been without value to those interested in the subject, that I have been encouraged and induced to continue the work, with a view to bringing it down as far as possible to the present time. In 1879 the conditions were different from what they are now. Then the subject of electric lighting was comparatively a new one, and the number of specifications to be examined, although extending over a number of years, was considerably less than the number issued between 1879 and the present year of grace. From an historical point of view my former paper necessarily possessed far greater interest for the student than the present one can possibly do, as it embraces so brief a period.

I have unavoidably been led to deviate in some respects from the plan formerly adopted, and to make this paper of a somewhat more practical character, in the desire to assist the student in his investigation of that particular system of electric lighting which may happen to be the subject of his search.

The abstracts of specifications given under each heading do not pretend to be even a *précis* of the whole of each patent. Indeed, such a compilation would be entirely beyond the scope of this paper or the limits allowed by the Society's *Journal*. The number of patents which have been taken out since the date of my last paper has been so great, exceeding 550, as to almost cause me, when I found the mass of work to be done, to hesitate before continuing it; nor should I have done so had I not known the great difficulty there is in obtaining even a mere list of the numbers, dates, and titles of the various patents on any particular subject, and therefore believed I could not fail to render some slight service to electrical engineers by undertaking this task.

Although in 1879 electric lighting was beginning to create considerable interest in the public mind, it had not assumed the vast importance it now possesses. The enormous amount of capital that has lately been embarked in various electrical undertakings, and the great number of persons not electricians who are connected with the subject, render it more than ever necessary that some system of classification should be attempted. It might well be thought that such a work should properly be performed by the Commissioners of Patents, who have the funds and all the material at their disposal for the purpose. Apparently its desirability, not to say necessity, has failed to strike them. It is true that an abstract of specifications on electric lighting has been issued by the Patent Office, but, although a recent publication, it only goes up to 1876. It will, probably, be admitted, therefore, that its usefulness is very much impaired, and, however thankful we ought to be for small mercies, we have not here much to be thankful for.

The limited time that I have been able to devote to the matter, and the great difficulty that exists in making a satisfactory classification of the immense number of patents produced during the last few years, have rendered the work one of great labour and considerable difficulty. I can only offer the paper as supplementary to the previous one, in the hope that the mere fact of bringing the various systems under one heading, with a few necessary subdivisions of all the published specifications to September 30, 1882, may prove of value to those who, in large and daily-increasing numbers, are devoting their attention to the subject of electric lighting.

I would here refer to the great assistance I have derived from the valuable collection of electrical patents presented to the Society by H.M. Commissioners of Patents. I have thereby been enabled to have laid before me week by week the whole of the published specifications on electricity and magnetism as soon as they were issued to the public, a fact which, I think, speaks well for the management of our library.

I would, however, suggest that, if the specifications were classed under their various headings, and bound up, or a classified index of them made, the labour of searching for any particular patent would be considerably lessened.

Mr. W. H. Preece, F.R.S., on the Munich Exhibition.

We do not intend to follow Mr. Preece *seriatim* in his paper, because we are already dealing with the exhibition in our other columns. We all know and admire Mr. Preece's ability to interest his hearers, and can say that this description of his visit to Munich was given in his best style. The paper, though long, did not weary, inasmuch as it was lightened by many asides and sly allusions to controversial points. We came in for our share of criticism, inasmuch as we had the temerity to "joke" the *Saturday Review* for its ignorance of Messrs. Ruston, Procter, and Co. We have wondered whom the *Saturday Review* writer might be—and whoever he is we can only say he sinned in good company—for Mr. Preece acknowledged that the firm mentioned was not particularly well known to him. The Munich Exhibition, although termed international, was so only in name—nor, indeed, was it really national, when such firms as Siemens and Halske, Felten and Guilleaume, &c., were unrepresented. It was, indeed, South German-Bavarian—intensely so. There was little new to chronicle, and that little of no very great importance. Great praise was given to Messrs. Crompton as having an excellent exhibit, and being the only English representatives at the exhibition. The Edison installation was noticed, as was that of Schuckert, whose machine was well spoken of. A secondary battery of an old type with a new name, and giving off in process of making a nauseous smell was mentioned, as was the new-old incandescent lamp with filaments like those of Swan, only shaped and interwoven spirally. That, with the hollow carbon, and other exhibits have already been mentioned in our columns. The lead-covered cables of Berthould and Borel were spoken of also as a new-old arrangement.

The archæological exhibits of the instruments of Sommering, Steinheil, Reis, &c., were mentioned, and so on. Reference was made to the phosphor bronze wires exhibited by M. Weiller, an exhibit which we have not yet mentioned. Mr. Preece seemed to think very favourably of this wire, and stated that a wire, 14½ B.W.G., was exhibited which would stand a strain equal to a similar wire of steel, and had a resistance similar to that of copper.

Mr. Preece insisted upon the fact that the Munich Exhibition would be known more on account of the tests carried out than for the apparatus exhibited. He justly spoke of the able men who undertook the work of testing as admirably fitted for their self-imposed task, as energetic, and greatly interested in the work. The testing instruments were all arranged previously to the opening of the exhibition, and so arranged that the crucial tests could be taken at the same time. The results are not yet ready, but will, no doubt, be shortly.

A hearty vote of thanks was given to Mr. Preece, subsequent to a short discussion, and the President announced that at the next meeting he should give a description of the experiences of the telegraphic work during the late campaign in Egypt.

THE ORIENTAL TELEPHONE COMPANY (LIMITED).

An extraordinary general meeting of the members of this Company was held at the City Terminus Hotel, Cannon-street, on the 13th November, 1882, under the presidency of John Pender, Esq., M.P.

The Secretary (Mr. W. G. Hall) read the notice convening the meeting, and subsequently the minutes of the last meeting, held on the 19th April, 1882, which were approved by the present meeting and signed by the chairman.

The Chairman then said: Gentlemen, the objects of calling you together to-day are, first, to ask you to confirm a sale of our rights to a company formed in Bombay, and secondly, to take powers to make similar sales elsewhere without the necessity of a special meeting. When I last had the pleasure of addressing you, I find, on referring to the speech I made on that occasion, that I made the following remarks: "We have not yet attempted any sales of privileges which we hold in India, but I expect before long (having established these important exchanges in the important

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centres of commerce I have mentioned, and looking to the number of the places which the Government wish us now to extend our system to) we may adopt the principle which has been adopted in England of forming small companies who will pay us a certain sum for the privilege which we possess, and that we shall also, at the same time, retain a certain interest in the working of those companies. That is the mode by which we propose to extend our system in India, keeping down our capital account, and basing our extensions on the creation of companies who will find the capital to carry on those extensions." The object to-day, as I have stated, is to ask you to confirm an agreement which we have made with a local company in Bombay for the purpose of carrying out our system in that presidency. We are to receive for our interest there in cash £30,000, and in shares £30,000, less certain expenses, which latter will continue, of course, in our possession. This gives us the advantage of local interest in carrying on the work, it gives us a very fair sum to begin with, and it also gives us about half of the working interest in that concern. Pursuing a different policy from certain other companies who have sold their interests before proving them in any place, we have thought it better to prove our system, showing people the benefits which are likely to arise from working it. That is the policy we have adopted, and the meeting to-day is to confirm the first important sale or arrangement in that direction. Before asking the solicitor to read the agreement I think it right that I should give you a short history of our present position, not only in Bombay, but in other parts of the East where we have established it. In Bombay we have something like 70 subscribers. They will be handed over to the new company, and I have no doubt that they will very soon make a very different show in the number. We have also secured as customers the municipality, the police, and the fire stations. We expect, too, to make communications for the Government, and where the Government take up a system it is generally an acknowledgment of its utility, and, consequently, others follow; and we know, as a rule, that wherever one merchant takes it up another must follow. In fact, it is one of those systems which is so concentrative that it becomes a positive necessity in a large commercial town that every commercial house should be in connection with the exchange. We therefore look forward to very marked success when it is, under local management, in the hands of men deeply interested in its promotion. In Calcutta we are endeavouring to follow out the same course; but any one who knows anything of India and of the peculiar mode in which India is governed will sympathise with us in the difficulties we have to contend with as regards the Indian officials. Unfortunately the English in India believe they should be omnipotent in everything, and it is very difficult indeed for what they call interlopers to have anything like a fair chance of pushing forward their interests; but I am happy to say that the present Indian Government—not only those at the head of the Government in India, but also those at the head of the Government in England—the Indian Government have taken a very different view, and are determined to pursue a very different policy. They have given me most positive assurances that we shall have fair play, and although we have taken a good many months to bring that about I believe eventually the small executive will be obliged to succumb to the large executive in enabling us to carry out our system. I may, however, mention that in Calcutta at the present time we have something like 100 subscribers. I hope the next time I meet you I shall be able to announce the formation of a company there. At Madras we have 30 susbcribers. The Government, however, are now having the system applied to their offices, and, therefore, we expect some more rapid extension there, but Madras is not celebrated for going very fast even as compared with the other presidencies. In Rangoon our last advices state that we have twenty-one subscribers there, and twenty-four police and post commissioner lines. This place also promises an increase. Kurrachee has been so far disappointing. Still, when the telephone is once introduced, and in such a climate, we cannot but be hopeful that it will be universally taken up by the mercantile community. In Colombo, Ceylon, we have thirty subscribers, and we anticipate a very considerable increase there. In fact, I believe it may be carried there to a much larger extent through connecting the different coffee estates which are working and putting them in connection with Colombo. In China we are making progress, but there also we have not gone quite as far as we expected. We found some of the merchants and some of the people there endeavouring to work a system among themselves. That is now at an end. It is being formed into one body now, controlled by us, and I hope, ere long, we shall be able to establish in China—at Hong Kong and Shanghai—independent companies. In Shanghai we have seventy-three subscribers. At Singapore we have a very active system going on. That system was well inaugurated by the manager of the Company—the Eastern Extension Telegraph Company—which I have the honour to represent. Our active and energetic manager there thought, as I have always said, that the telephone would be a feeder to the telegraph, and he established what has turned out a very successful system, which we purchased at little more than cost. We had to pay something to a few persons connected with him, and something for the work done, but, as far as the materials are concerned, we paid the cost only—£2,990—in cash, and an equal sum in fully paid £1 shares in this Company. At the present moment there is a gross revenue of £1,600, and a net revenue of £1,100, so we have a return on our investment. There I may mention there are about seventy subscribers. The place where we had made greater advances than anywhere else was Egypt, when the unfortunate crisis took place, but I am glad to say that we are almost already in good working order there again. The Government have taken it up. It was proved to be of very great use during the time the Admiral had possession of Alexandria—so much so that he addressed a letter of thanks to the Company's agent for the great use the telephone proved to him during the time of the occupation. We shall also, I have no doubt, be recouped by the Egyptian Government for the injury and loss we sustained during the crisis. At Cairo our system is connected with the palaces and different offices, and we have sixty subscribers there. At Alexandria we have ninety-four subscribers and twenty-one connections with the Government offices. We hope in a very short time to establish an independent company there. We have received a letter to the following effect:—"The reinstatement of telephonic communications in Alexandria is approaching completion, and by next mail I hope to send you a list of subscribers connected up. It is a sign of the progress of the telephone to be able to state that notwithstanding the revulsion of affairs in Egypt we have virtually not lost a subscriber." We all know the destruction that took place at Alexandria of house property, and consequently we have a good deal before us when the city is rebuilt. I therefore look forward to Egypt being a very important station indeed. We have, notwithstanding the state of things which has prevailed there, received a first remittance. It is not a large amount, it is true, but it is the beginning of money coming from Egypt, and no doubt once started we shall be receiving it steadily. The first system that we had opened, which we took over from the vendors, was in the Hawaiian Islands, and our agent there, writing on the 21st of September, stated, with regard to the exchange at Honolulu, that there were 232 subscribers connected, and applications from 30 more. Well, that is in a place where we could scarcely expect such a number of subscribers, and it seems to be growing as fast as the other places. I think you will agree with me that, looking to the very favourable field we occupy, the development of the business is only a question of time. Sir Julius Vogel is in Australia now, and is looking up that part for us; but the fact is that altogether we have about as much in hand now as our capital enables us to deal with. We have only had £60,000 in cash to carry on the work, and until we sell some of these systems, so as to get a return, such as we are getting from Bombay, we think it is not desirable to push the business unduly so as to place us under the necessity of making a call on the shareholders. We think we can meet those requirements better, and, perhaps, in a more agreeable way to the shareholders by issuing 20,000 of the shares which we kept back from the vendors in the settlement with them on account of some irregularity. We retained 25,000 of those shares, and we propose to issue 20,000. Those shares to-day are quoted at something like 16s. in the market, and we propose to issue them at 12s. 6d. in other words 2s. 6d. above par, giving the shareholders the opportunity of taking them *pro rata* according to their holdings. That will give us something like £10,000—for there is only 10s. paid up on our shares—and with the sum coming to us from Bombay I hope we shall be able to pay our first dividend to the shareholders. That will probably be after the end of our financial year. These remarks will give you some idea of our position, and I will now give you these details: At Alexandria we have 94 regular subscribers, 21 Government subscribers, and there are applications for 17 more. That is altogether 132. At Cairo we have 60 subscribers. At Bombay we have 73, and eight for the military, police, and other stations, making together 81. In Calcutta we have 108 subscribers. At Madras we have 30 and four for the Government, making together 34. At Rangoon we have 21 subscribers and 15 for the Government, being together 36. At Kurrachee there are 15 subscribers, at Colombo 30, at Hong Kong 15, at Shanghai 73. At Singapore we have 38 subscribers, and 32 for the military, police, and others, together 70. At Honolulu we have 232 subscribers, and 57 more applications, making together 289. The total number of subscribers, connected, or who have applied, therefore, is 943. That is the position, gentlemen, we occupy to-day. The solicitor will now read the agreement with the Bombay Company.

The SOLICITOR (Mr. A. G. Renshaw) having read the agreement,

The CHAIRMAN said: Then the resolution is as follows:—"That this Company hereby approve, ratify, and confirm an agreement dated the 8th of August, 1882, and made between Clement Davidson Leggatt, as the agent of this Company in India, of the one part, and John Grey Russell, as the trustee for and on behalf of a company then about to be formed and incorporated under the name of 'The Bombay Telephone Company (Limited),' of the other part, whereby it has been agreed, subject to confirmation by this Company, to sell the business, goodwill, plant, and property of this Company in the Bombay Presidency, Scinde, and Hyderabad (Deccan), to the said 'Bombay Telephone Company (Limited);' and do hereby authorise and require the directors of this Company to carry such agreement into effect, either with or without any modification or new terms which they may agree to on behalf of this Company."

Mr. PATRICK CARNEGY (a director): I have the pleasure of seconding that resolution.

The CHAIRMAN: Before I put that, if any gentleman has any remark to make, I shall be glad to hear him.

Mr. ST. JOHN ACKERS: Is there any real meaning in those words in the agreement as to "native States?" There is nothing in the resolution about native States, but the agreement says there shall be the right to the Bombay Company to sell, or whatever the term may be, the right of the Company in native States of India. That is not mentioned in the resolution.

The CHAIRMAN: The resolution is to approve the agreement we have made with the Bombay Company—the agreement you have heard read. The limit of the Bombay Company is given in that agreement.

Mr. ACKERS: Then that extends far beyond the resolution. The resolution mentions certain places—for instance, Bombay, Scinda, and Hyderabad (Deccan). Do I understand that those are native States?

The CHAIRMAN: They are included in the agreement with the States the Bombay Company has the right to work.

Mr. ACKERS: All over India?

The CHAIRMAN: No, not all over India. They are confined to these places. We have the work at Calcutta and Madras, but this is what belongs to the Bombay Company.

A SHAREHOLDER: It is rather indefinite—what this gentleman refers to—the allusion as to the native States of India. It struck me at the time it was being read that that was rather indefinite. I said to a gentleman next me, as to the words "native States," that means all India. I think it advisable that the solicitor should look to that part, and point out whether I am correct or not.

The CHAIRMAN: "Native independent States." This is very much in the position of a gentleman who has a private domain. They are entitled to put up the telephone in such places. In fact, the more they put it up in these outlying places the more money we shall get.

In answer to Mr. ROBINSON KENDAL,

The CHAIRMAN added: What is meant is an independent State not under the rule of the English Government. It is very much in the position of a gentleman who has an independent property in India. The Bombay Company will be entitled to deal with such gentlemen.

Mr. KNIGHT: The native States of India are very numerous. Some are under the political control of the Supreme Government of India, and others are under the control of the Bombay Government. In the agreement with the Bombay Company, I should think by "native States" you meant those States within the control of the Bombay Government. The State of Hyderabad is not under the control of the Bombay Government, but under

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the political control of the Supreme Government of India. I should think, as the agreement was read by the solicitor, that the expression "native States of India" would mean all the native States unless qualified by some words to the effect that they were such native States as are under the control of the Bombay Government. I do not know whether it would be of any great importance, because I do not feel sure that our patent laws run to any of the native States. The matter ought to be defined whether it means all the native States of India or only those under the political control of the Bombay Government.

The CHAIRMAN: I think you must take this view of it. These are what we call independent States. They are independent so far as their revenues are concerned, but they are subject, more or less, to the supervision of the British Government. They are outlying places which it is very material to us to have worked. It would be impossible for us to form a company to work those places alone, and as we are proprietors of a very large portion of the Bombay Company's capital the more of those places they choose to take up the better for us, as we shall get a greater revenue out of it. If we go to Calcutta we shall take a radius in the same way, but the great thing is to get these, what we call independent native States, worked. They are apart from one another, and it is necessary to have them worked by one organisation, and we believe it will be better that they should be worked by the Bombay Company, as we believe there is more enterprise there than in any other State in India. The more those places are worked the greater the revenue that will accrue to us. If they find they make a good bargain there we get half of all they make, and I cannot see that there is anything very far wrong in giving them the run of what they call independent States. Again, in those independent States those who first get possession will derive the greater benefit, because I am informed that those native States do not grant patent rights as they do in other places in India. Therefore the sooner they are occupied the better for the possessors. This matter must have been well considered in Bombay, where this agreement was drawn, so as to get the greatest amount of revenue for the Company.

Colonel GOURAUD (a director): I think that the importance of the question raised is entirely covered by the fact of our possessing such a large interest in that company. If we were not shareholders in the Bombay Company, I don't think we could over estimate the importance of the question raised, but being the largest shareholders—having half of the capital—the wider the Bombay Company extends its operations the better for us. It furnishes the capital, and we have half the profits. I should like now to depart from the usual course on such occasions, and say a few words rather as a shareholder than as a director. My excuse for this will be perhaps better understood if I refer to my large interest as a shareholder in the Company, and to the fact that I have taken an insignificant part in the negotiations which have resulted in the sale of these rights to the Bombay Company. But for that I should scarcely venture to state what I am going to say. The explanation of my taking no part on the working of the Board of that company is due to the fact that I was not in the country when the negotiations took place. On my return, it being the first sale of the concessions of the Company, and it being the beginning of the policy pointed out by the chairman at the last meeting, and being so largely interested as a shareholder of the Company, I made, perhaps, what was an exceptional investigation of all the terms of the contract. I have had opportunities of doing so such as no other shareholder has had, naturally, and I have done so very thoroughly; and I am happy to say—and you will be all glad to hear it from me as a shareholder and not as a director—that it is a favourable contract for this Company. My opinion may carry some weight on that point when it is taken into account, as it may be, that I have had something to do with all the telephone contracts made since the birth of the telephone; and I regard it as an especially favourable augury for good that on behalf of this Company your directors have been able to form a Company on the terms on which this Company is formed, and with the excellent local support it has received on the part of the Bombay merchants who have joined the Board, who are responsible to the public for the issue, and who will be really responsible for the management in Bombay. While we congratulate ourselves on the arrangement we have made, we must be careful that those self-gratulations shall not be construed by the parties on the other side into meaning that it is a hard bargain for them. They, perhaps, will hear what we say, but this is one of those cases where both parties give and take. We had something to give—something they wanted, something they could not get on without. This may seem a broad statement, but I make it in the full breadth of its possible meaning: There is, I contend, no civilised body in the world that can get on without telephonic communication. Therefore they wanted it, and we agreed on what terms we would give it to them. They gave us, on the other hand, the inestimable advantage, where the business is conducted so far from home, that feature on which the chairman touched, namely, the advantage and importance of local support. That if in right hands ensures the success of an enterprise like this, and that statement has the broadest possible authority. The telephone, as you know, came from America. The Americans who brought it here (I happened to be one of them) did not seek to carry it out themselves. We did it as far as we could—as far as our means allowed; but as soon as we inaugurated it, and showed what it was, as this Company has done in Bombay, we looked for gentlemen to take it off our hands. We still hold a very large interest in it. That fact has explained the great success the telephone has had here. I venture to say that this Bombay Company will be a very great success. I cannot see how it can possibly fail. Having said so much from the shareholders' point of view, I wish to say one or two words from the directors' point of view. I wish to say them to the shareholders of the Company, and I presume I am speaking to shareholders in a good many other telephone companies, and it is this: There is one thing not generally appreciated or understood in this telephone business. It bears with great significance on the value of telephone share property, and when I say telephone share property I rather mean that class of telephone property whose business is chiefly, if not exclusively, what is known as telephone exchange business. It is this—that where you once establish a telephone exchange in a mercantile community you have got the safest kind of investment for your money, for this reason, no one who ever uses the telephone for business purposes gives it up unless he goes out of business by reason of making his fortune or by reason of bankruptcy (and there are more people who use the telephone who go out of business through making their fortunes than retiring from the other cause). It is a fact noticed by the United Telephone Company—of which I am a director—that in not a single instance where a party has subscribed to the exchange has he ceased his subscription because of the telephone being of no use to him. There is not a single instance of that in my experience, and I say this on the strength of considerable experience, since the beginning of the telephone, and as a director of half-a-dozen telephone companies, whose operations extend round the world. There is the further fact, too, of the impossibility of competition. I know of no monopoly in business that is so certain a monopoly as the telephone business, for the reason that there cannot be two telephone exchanges. Generally monopolies are considered objectionable, but this is a kind of monopoly essential to the interests of the people who use it. Hence it is a monopoly with the very best security. As an illustration of the argument—it is the first time I have made it, and I have never heard it anywhere—I may mention that in a foreign concession which I have recently been one of a party to acquire, the Government has actually stipulated that it shall be a monopoly—an exclusive concession for ever, as long as the business is done. That bears very great significance on the value of telephone share property, and it is a good thing for all of you to know it. None of you can ever lose money by knowing it, and some of you may make money by the knowledge. I support the resolution on behalf of some 60,000 odd shares in the Company.

Mr. KNIGHT: I did not rise to object to the resolution. I saw there was some uncertainty in the meeting as to what was meant by "native States." I think you said that the enterprise of the Bombay community was very favourable to this enterprise, and, as we hold so large an interest in the Bombay Company, I am not a party to object to the concession covering all the native States, only I think it should be understood that that is so.

The CHAIRMAN then put the resolution in the usual way, and declared it carried unanimously. Continuing, he said: The next resolution I have to propose is as follows:—"That the clause or sub-section marked (*c*), contained in the 60th of the Company's Articles of Association be repealed, and that, in lieu thereof, the following shall henceforth stand and be the clause or sub-section marked (*c*) contained in the said 60th Article—that is to say:—'(*c*) They may of their own authority sell all or any part of the business, goodwill, patents or patent rights, and property of the Company, or the business, goodwill, patents or patent rights, and property appropriated for, or appertaining to, any branch of the Company's business, either wholly or partially, for cash or for shares, debentures, or other interests in any company or corporation, or to any person or persons; and if deemed expedient the directors may hold or (so that the capital of the Company be not thereby reduced) distribute in specie among the members in proportion to their holdings, or otherwise deal with such shares, debentures, or other interests.'"

Sir A. ARMSTRONG: I beg to second that.

Mr. ROBINSON KENDAL: I understood you to say that you had withdrawn from the vendor 20,000 of the vendor's shares.

The CHAIRMAN: Yes.

Mr. KENDAL: And that you now propose to issue them to the general body of the shareholders. I understood that those vendor's shares were in the nature of deferred shares, not entitled to dividends as ordinary shares. If that be so—and I speak under correction—I wish to know how you are going to issue those deferred shares. Have you the power to do so?

The CHAIRMAN: I think that is a very proper question to put, and the solicitor will explain it, but we should not have proposed to you to-day to issue those shares unless we had taken the best opinion as to our ability to do so. We are quite justified in issuing these shares, because they are really original shares, and have never been issued. We simply retained them. We did not pay them away, and they stand in our possession as original shares. I am very glad you have put the question, and I believe that the solicitor will give you an opinion that will satisfy the shareholders.

Mr. KENDAL: While I am on my legs may I ask you to say, *ex cathedra*, what is the exact position of the ordinary shares and the deferred shares of the Company. I have had at least a dozen conversations with gentlemen as to their position, and as to whether the deferred shares get nothing for six years or some other period.

The CHAIRMAN: The vendor's shares are deferred shares, or shares upon which they are not to receive any income for five years. The shareholders must receive 6 per cent. before they can receive anything, and that is deferred for five years. If we were to earn 12 per cent., the deferred shares would get 6 per cent., but they cannot get anything for five years unless the shareholders during that five years have received 6 per cent. on their shares.

A SHAREHOLDER: Does that mean if the ordinary shareholders receive 6 per cent. for five consecutive years that then the deferred shares would get a dividend, or does it mean that, no matter what dividend is paid on the ordinary shares, the deferred shares shall not be paid till the end of five years?

The CHAIRMAN: At the end of five years the deferred shareholders come into payment with the ordinary shareholders. That is, if the ordinary shareholders have received 30 per cent. They must receive 30 per cent. before the deferred shareholders receive anything. I think it would be well for the solicitor to read counsel's opinion as to the shares, so that the public may be perfectly assured that these shares now proposed to be issued are in precisely the same position as the ordinary shares.

A SHAREHOLDER: Suppose 60 per cent. could be distributed in the five years, what would become of the remaining 30 per cent.?

The CHAIRMAN: The ordinary shares must receive 30 per cent. before the deferred shares receive anything. After we have received 30 per cent., then, if we can afford anything over that 30 per cent., the deferred shares get their proportion.

Mr. KENDAL: Suppose you earn 30 per cent. in two years, will the five years' clause be abrogated at the end of that two years?

The CHAIRMAN: Certainly. After we pay 30 per cent. the deferred shares come in.

The SOLICITOR: The Company was constituted with a capital of £300,000, divided into 300,000 shares of £1. There were no deferred shares under the Memorandum of Association of the Company. The deferred shares were only made such by the contract with the vendors, and, therefore, when that contract was modified the shares became, as before,

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ordinary shares of the Company. If you like I will read the opinion of counsel, which we took some time ago when these shares were reserved from those issued to the vendor. He then read the opinion.

Mr. ACKERS: Before the motion is put I should like to ask who the present directors are?

The SECRETARY: The present directors are Mr. Pender, M.P., Sir Julius Vogel, Sir A. Armstrong, Sir William Thomson (*ex-officio*), Mr. Patrick Carnegy, Mr. James Pender, Mr. John P. Bigelow, Mr. W. W. Cargill, and Colonel Gouraud.

The CHAIRMAN: The gentleman who has put that question to me called on me the other day and remarked that there were three other names originally in the prospectus—Mr. Thomas Alva Edison, the Hon. G. G. Hubbard, and Professor Bell. Those are the gentlemen whose names are so much associated with the telephone. It appears that, according to our rules, a director must give certain attendances within six months, or otherwise he ceases to be a director. Those three gentlemen gave their names to the Company simply on account of their association with the patents, but as they live in America it was impossible that they could come over and attend our Board meetings. Their names were necessarily, in accordance with the Articles of Association, dropped out, but if it is desired by the shareholders I believe that those gentlemen would be only too glad to remain as honorary directors by our re-electing them, or altering the Articles of Association of the Company, so as to make them permanent directors. That is the simple reason why they are not now on the Board.

Mr. ACKERS: If that is carried out I shall be most thoroughly satisfied. I have the greatest possible confidence in the English directors—in you and all connected with you. At the same time I am more especially interested with the names of those gentlemen who started the telephone, and who are mostly resident in America. Their names, I believe, give additional weight and confidence to the working of our Company, and if you do what you suggest, either retain their names or alter the Articles of Association, I shall be satisfied. I think there is an unintentional inaccuracy in what you stated. They do not absolutely cease to be directors if they do not attend, but only if they absent themselves without leave. If you give that leave, except when they are in England, they will be reinstated. We owe much to the Americans, and, with your explanation, I hope that these gentlemen may continue to be directors of the Company. I trust also in your discretion, and the discretion of the rest of the Board, the arrangements you may make with other companies may be equally successful with those made at Bombay.

The CHAIRMAN: I may say that there never was any consent asked by these gentlemen for their absence. I may add that this has occurred during my absence in America. I have been to America myself and have seen them, and the opinion expressed by the gentleman who has just spoken I quite agree with. I also entirely agree with the sentiment he expresses, and I believe if I had been at the Board this would not have occurred. I think men whose names are so honourably associated with the starting of the telephone system are men whom we should keep among us even as honorary directors, showing that they still feel an interest in the growth of their children. I have not been back a fortnight, and if you had asked me the question I should have said that these gentlemen were on the Board. Now that attention has been drawn to the subject, I shall take care, unless these gentlemen have some objection, that we re-establish their names on the Board. I think we will, if you wish it, do so now. I beg to move that those gentlemen be reinstated on the Board.

Mr. ACKERS: May I be allowed to second that?

Mr. KENDAL: I think you cannot do this. The Act of Parliament especially stipulates what you can do.

The CHAIRMAN: Perhaps that is so, but this is an expression of our opinion. Before I close the business of the meeting I may mention that, during my visit to America, I had occasion to see a great deal of the telephone, and I was struck with the extent to which it is used there. In fact, it seemed to be so much employed that if you wanted any little information you got it almost immediately through the telephone. It caused me to look to statistics as to the telephone generally throughout the world, and there is a little book just published that I would draw your attention to. It is in French, and it is called the "Compagnies Internationales Telephones." I find on looking to that little pamphlet that in America—and they state that they cannot get the information there accurately—there are 37,187 telephones; but it is stated that this probably only represents one-third of the telephones used. As a matter of comparison they give at the same time the number used in Great Britain, and that is stated at 4,946, while they have got for us in India 700. I have told you that to-day our number is 943. But when you see the use of the telephone in America, and see how very few there are in use in this country and in India, I think I may say there is a very wide field for telephonic enterprise.

DR. JOHN RAE: I have just returned from a new city, Winnipeg, and I can assure you that the telephone is in large use there. A friend of mine was asked to dine a couple of miles from town, but the weather turned out very bad, and just as he was about to start he received an intimation by telephone—this was two miles from town—that they did not expect him. Winnipeg was nothing but a village two or three years ago, but now it has 25,000 inhabitants. They have the telephone everywhere, and the electric light is just starting. That bears out all that the chairman has said.

The CHAIRMAN: From what I saw in America I felt a little ashamed that we are so much behind in this thing. I was at Winnipeg, too, and saw electricity going ahead very considerably.

A SHAREHOLDER: Will you allow me to suggest that the second resolution has not been put?

The CHAIRMAN: I beg your pardon, we were getting into rather a conversational state. He then put the resolution, and declared it carried unanimously—adding that that finished the business of the meeting.

A SHAREHOLDER: I beg to propose a hearty vote of thanks for the able manner in which you have presided over us.

A SHAREHOLDER: I beg to second that.

The CHAIRMAN: I am very much obliged to you on behalf of my colleagues and myself. We have given you all the information in our power, and we have shown you that there is a very wide field for telephonic enterprise. It is the youngest of what are called the electrical children—younger than the light; and I hope as we meet from time to time this Company will show the expansion which the extensive field it is occupying would warrant us in expecting.—The proceedings then terminated.

THE BRUSH MIDLAND ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

An extraordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel, on the 14th inst., "to consider the adverse proceedings taken by certain shareholders against the Company, and to pass a resolution authorising the directors to continue the business of the Company, notwithstanding the proceedings of the dissentient shareholders." Mr. R. H. Glyn presided.

The SECRETARY (Mr. H. N. Myers) having read the notice convening the meeting,

The CHAIRMAN, in the course of his address, said: Certain shareholders—and I am glad to say they are small in number and represent only a small amount, in fact eighteen shareholders out of over 800, representing only 149 shares—taking advantage of what they allege to be a misstatement, or I should say a material misstatement, in the prospectus, thought fit to bring actions against us for the return of their money. I daresay some of you have noticed—probably with no very great pleasure—that a petition in Chancery was filed to wind up this Company. This, however, was done by a friendly and a large shareholder, who has no wish whatever to wind up the Company, but who does not wish that these 18 gentlemen should come in and get any priority of claims over the rest of us supposing that this statement in the prospectus turns out to be material and we are ordered to return the money. All this fuss and bother has come from a word used in the prospectus—the word "exclusive." It was stated in the prospectus, which was issued in May, that the Company was going to buy an exclusive concession for two things from the Anglo-American Brush Electric Light Corporation—a dynamo machine and the Lane-Fox lamp. Now it is not, and cannot be, denied by any one that we have the exclusive right to that very valuable concession of the Brush dynamo machine, but it is pretty nearly clear, I think, that we have not the exclusive right to the use of the Lane-Fox lamp. The first question that will naturally arise is, how came we to say that we had, if we had not, an exclusive right to it, and it is very hard to answer this question. Whether the Anglo-American Brush Corporation purposely suppressed the fact that Mr. Lane-Fox had given a license, I think it is to the British Electric Light Company, or not I do not know. Whether they did it in innocence, not knowing what they were selling, I do not know; but it is quite clear that we have only a *pari passu* right with the British Electric Light Company to the use of the Lane-Fox lamp in our district. There is another very remarkable feature in this matter. On the Board of one, if not more than one, of the companies who have used this word "exclusive" are directors who are directors also of the parent Brush Company. If any one can be made to suffer for this mistake it shall be done. Another curious fact about the mistake is that it passed so many solicitors of high standing, and I take it that the reason for that fact was this—you must understand distinctly that we never paid a single farthing for the Lane-Fox lamp. What we paid for was that very valuable concession of the Brush dynamo machine, not a cent for the Lane-Fox lamp, and I take it that the real secret is that the solicitors, saying that "they have paid nothing for it," did not go so carefully into the rights as they might have done. We have not lost sixpence from the want of this exclusive right. There are two courses before us in consequence of these actions—one is liquidation and the other is going on. Now I do not think many gentlemen here can consider the sound of the word "liquidation" is pleasant; and how should we stand if we were to liquidate? We should have, first of all, a certain amount of machinery—call it £6,000 worth, and then our great asset would be our concession from the Brush Company. Now, I do not think any one at present would give any large sum of money for an electric light concession, because we know that electric lights are rather in low water at present, and in the hands of a liquidator would not fetch much. If, therefore, we were to liquidate, it would, putting aside something I shall tell you about presently, be suicidal—indeed idiotic. Now we come to the other alternative—shall we go on? And the first question that arises is what we have done up to the present time? The prospectus was issued in the middle of May, and of course it took a long time to get it into ship-shape. We had to get agents, and officials, and that sort of thing, and I may fairly say that we have been actually working for only four months. In those four months we have actually paid our working expenses, and those expenses include not only advertising and the running about to get orders—because up to the present time people have not been asking us to put up the light, we have to go to them for that—but it also includes several installations we have been obliged to make as advertisements in various places—Boston, Leicester, Reading, Gainsborough, and Grimsby, and we found it absolutely necessary to show that our light would burn. Well, all that we have had to pay for. I have told you that we have made all these installations, and you must understand from what I have said, that we have paid our expenses, that we have made some money out of some one. We have to speak of the chief work, lighted up the town of Cleethorpe, a place in one of our districts, and we have done it very successfully. That is the arc light, and arc lighting is our profitable business. The incandescent light does not appear yet to be sufficiently perfected to justify going out of your way to beg for business. You must bear in mind that our district is mainly one of factories, and where we get the power supplied a manufacturer can afford to put up the light much cheaper than if he had to put up the machinery. As I say, we have lighted up Cleethorpe, and I think we shall there get some incandescent lighting. We have done very well indeed at Nottingham. We have put up an installation there in the factory of a firm very well known, who are so satisfied with it that they have invited their friends to go and see it. We have done the same thing for another large firm at Nottingham. At Lincoln we have done some very good business. We have also got the following contracts, which are either about to be settled or which we shall get; and I think when you listen to what I have to say you wil be rather astonished that our officials have done what they have. In Oxfordshire we have no fewer than five contracts ready, and we do not put up any light unless it pays us. At Nottingham we have four; at Leicester a most important one, which it will not be for the interest of the Company that I should mention; at Carnarvon one, at Chester one, at Cleethorpe we shall get a large quantity of work, at Stockport one, at

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Fordingham one, and at Leicester two. You must not forget that every installation we put up not only pays us but is also an advertisement. All these contracts I gave instructions to the manager myself were to await the decision of this meeting. If you choose to liquidate, all these contracts go to the wall; if you go on there is profit enough in my opinion to pay you a very fair dividend. If this time next year we should not be able to pay a dividend we should at least pay our expenses. I shall now read the resolution which we propose to pass, but which I shall not put immediately. It is as follows:—"That this meeting, having heard the statement of the chairman as to the position of the Company, is of opinion that the business of the Company should be continued, notwithstanding the proceedings of the shareholders who have demanded the return of their money; and therefore request the directors to arrange for the immediate withdrawal of the petition."

Mr. BEDFORD observed that the shareholders could not fail to have been gratified at what the chairman had stated concerning the progress of the Company. In compliance with the wish of the chairman, he referred, from personal observation, to the enormous progress in the United States since 1881 of the electric light, and particularly of the Brush arc light. The question was, was it a permanency? He could only say that the lights appeared to have been put up in a substantial manner, not on the old lampposts, but on regular lampposts for the purpose, something like 40ft. or 50ft. high. The gas lamps, too, had been dismantled. The price of gas had been reduced from 3 dols. to 2 dols. per 1,000 cubic feet.

The CHAIRMAN: I may inform the meeting that at Cleethorpe the gas company in a rage took up all the gas mains.

Mr. BRAITHWAITE could not but think that the shareholders should be rather glad than otherwise of the incident referred to which had enabled them to meet the directors, and hear the very satisfactory and frank statement of affairs that had been laid before them. When they looked at the position of the Company he thought they had every reason to be satisfied. They found that the patents which had been acquired by the Company gave them the exclusive use of the celebrated Brush dynamo machine over fourteen counties of England, and he ventured to say that a right like that to use the Brush dynamo machine, which, he said, was admitted on all hands to be the most efficient—was no trifle. As to the Lane-Fox incandescent lamp he had used it in his own house for three months, and had not broken a single lamp since he began their use. As to their not having the exclusive right to use it that was a play on the word. If the British Electric Light Company sold it at all they must, by their agreement, give it another name. He expressed his entire confidence in the future of the Company with its small capital of £60,000, including the call payable the next day. They were now doing a sound, remunerative, and increasing business, and he believed they had a good prospect of a dividend at no distant day.

Mr. STUART thought the principal question for the meeting to consider was, how the persons who were bringing the actions were to be met?

The CHAIRMAN: If the worst comes to the worst it is only a question of £250.

Mr. STUART: But others may follow.

The CHAIRMAN: I think not after the expression of this meeting.

Mr. STEWART thought that the question raised had nothing to do with the object for which the meeting had been convened.

Mr. BRAITHWAITE pointed out, as regarded the suggestion of other shareholders following the course taken by the 18 shareholders alluded to, that, if necessary, the shareholders could sign any circular sent round by the directors stating that they condoned the error in question.

The CHAIRMAN then put the motion, and declared it carried with one dissentient—a gentleman who stated that he held 10 shares.

On the motion of Mr. W. PAYTON, a vote of thanks to the chairman was passed, and the meeting separated.

YORKSHIRE BRUSH ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

A special general meeting of the shareholders in this Company was held at the Cannon-street Hotel, on the 15th inst.

Mr. H. W. LOWE presided, and stated that the meeting was one of the greatest importance—in fact, they had to decide on a matter of no less interest than the continued existence of the Company or its immediate dissolution. In view of the recent action of one of the shareholders the Board decided to convene that meeting at the earliest practicable date, that the shareholders might attend and receive a full explanation as to the affairs of the Company. He had first to call attention to the circular issued by Mr. Charles P. Whiteley, and denied the accusations it contained. The directors did not proceed to allotment till 36,632 shares had been duly applied for and the money paid into their bankers. In his second circular Mr. Whiteley asked the directors to deny if they could that they had held meetings with the directors of some of the other incriminated companies over this business, or that they had met the Hammond Company and tried to get concessions from them as compensation for the blunder. Well, he was glad to say that the directors had not, either individually or collectively, been present at any such meeting, nor had they had the slightest intercourse with any representative of any other company. He also denied most emphatically that they had had any meeting with the Hammond Company or tried to get any concessions from them of any kind. At the earliest meeting of the Company the directors read over the two licenses very carefully, and no one ever entertained the slightest idea that there was anything in them but that they were intended to be exclusive licenses granted to them. The language of the licenses appeared then, and did so now, to the directors to be direct and exclusive, and he must point to the several other companies in proof that the directors of this Company were not alone in that view. Not one word was ever heard of any doubt or question on this subject until Sir Charles Bright wrote, on the 3rd October, and pointed out that there was a concurrent license granted to the British Electric Light Company. He desired to say nothing which could interfere with any legal rights they might have against the Brush or the Hammond Company for any compensation, but he was frank to admit that they had not so lost one farthing. They had no fear of loss from the competition of the British Company in Yorkshire, but if so he ventured to assert that the Lane-Fox lamp, as now made by the Brush Company and sold to this Company by the Hammond Company, owing to the improvements made in it, was of infinitely greater power than the lamp to which the concurrent license applied, and the British Company had no power to get from the Brush Company this splendid improved Lane-Fox lamp. They were now just completing the installation at Middlesbrough of the forty lights that were worked on the rental system; and he felt sure from the promises they had received that that work would be repeated to the same extent. They had given up the idea of exhibiting or doing any work for nothing; they declined all work which did not give them a profit. They were negotiating also for an extensive amount of work, and they expected to get as much as would keep them at work. Their expenses were kept down to a very low point; they had no preliminary expenses to write off, and they began with a clean sheet. Even if they did not make sufficient to pay a dividend at the end of the year they would show that they had not been wasting money. At present they had to oppose the enormous monopoly of the gas interest, and they could not expect with a novelty like the electric light that its progress would be at once rapid; it must, in fact, be gradual. The directors considered that the Company was making fair and satisfactory progress, and at no great expense. The prominent question was, should the Company at the wish of a few discontented shareholders, and at the instigation of one of them, be wound up and cast adrift? Adding the enormous charges of the lawyers and liquidators, and the usual expenses of winding up, nothing could be left but the ashes for the shareholders. He had no other interest but to make the Company a success. He would, before submitting the resolution he intended to move, ask Mr. Phillips, their consulting electrician, to give them some practical explanation as to the Lane-Fox lamp.

Mr. PHILLIPS accordingly proceeded to explain the nature of the original Lane-Fox lamp, and the improvements which had been made in it. He stated that the lamp they had now was as different from the former lamp as could be imagined. The cost was considerably less, no doubt, and would be rendered still cheaper: and it could be better made and sold at a profit at 3s. or 4s. than the former at 6s. or 8s. They could, too, fit it now for 1s. or 1s. 6d., instead of 10s., and it could be sold throughout Yorkshire at a handsome profit of 4s. or 4s. 6d.

The CHAIRMAN then moved: "That this meeting hereby empowers the directors to carry on the business of the Company and to oppose the winding-up petition lodged by Mr. Whiteley, and to take such steps as they may deem necessary for the protection of the Company's interest."

Mr. BROUGHAM, in seconding the motion, expressed his regret that such charges had been brought against the directors, who were gentlemen of high character and well known.

Mr. WHITELEY said that the chairman admitted that the directors thought when they bought the concessions that the licenses for the Lane-Fox lamp were exclusive, and that admission had proved his case. The directors, however, said that though the licenses were not "exclusive" they were "full," that that was about the same thing, and that the Company had not been damaged. He maintained that that was a most improper position to take up. He could believe that no damage had been done so far, but what was there on the credit side? He was not prepared to press criminal charges against the directors, or to charge them with dishonourable conduct. He defended the position he had taken up, and stated that he had none but perfectly honest intentions. Turning to the prospectus he made several references to and quotations from it with the view of showing that the shareholders had been induced to subscribe their money on misleading statements. It was, for instance, stated that allotment would not be made unless 35,000 shares were *bonâ fide* subscribed by the public. He contended that nothing like that number had been subscribed for. There were, therefore, 11,633 shares left. The chairman had suggested that he had taken isolated action, but he had 101 shareholders behind him, representing 2,949 shares. He contended that he had shown that they had been grossly misled—he did not say by the directors, but it was to the directors they looked. He had read Mr. Hammond's statement as to the Ferranti machine, and he inquired if that meant that that machine was going to supersede the Brush machine. If so, what had they paid their money for? Supposing that £2 a share had been paid on the 61,633 shares there was a capital of £123,266, of which, according to the prospectus, £100,000 was to be paid for the concessions. That left them, in the most favourable view of the case, with a capital of £23,266 to work an area described in the prospectus as one-ninth of the whole of England. It followed, too, naturally, that out of every £123 earned £100 would go to the promoters and £23 to the shareholders. What chance, therefore, was there of making this a successful Company? He asked the meeting for their support on these grounds, and ventured to assert, in conclusion, that even if the Company went on now it must fail eventually.

Mr. H. B. SEELEY complained that the Company had been illegally formed, as the number of shares mentioned in the prospectus had not, he said, been subscribed for by the time fixed for closing the lists.

Mr. M'ALISTER supported Mr. Whiteley.

The CHAIRMAN, in reply, again denied that there had been any of the "furtive meetings" alluded to by Mr. Whiteley as regarded the directors of this Company. With regard to their not having the exclusive license to the Lane-Fox lamp—a fact which came on them entirely unawares—no one had raised the slightest question about their exclusive rights to the use of the Brush machine, and the word was exactly the same in both cases. They, however, wrote to the Hammond Company, requesting them to explain the circumstance. They received a reply, stating that the Hammond Company was in communication with the Brush Company on the subject, and they would answer the communication from this Company as soon as they heard from the Brush Company. Immediately after that came the petition to wind up the Company, and Mr. Whiteley's circular. The directors at once then decided to await the result of that meeting before proceeding further. He felt sure that the Hammond Company had always behaved most honourably to this Company and their other subsidiary companies, and he was certain there would be no difficulty in their meeting this case to the satisfaction of most of them, if not all of them. As far as they could learn the Hammond Company had been taken as much by surprise as any of them. If they had suffered any damage they might depend upon it that the directors would do all they could to rectify it.

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The question of capital rested with the directors, who knew the kind of business they were going to undertake. If they had had £50,000 or £70,000 they would have had to bank it. They had paid nothing for the Lane-Fox license. The Brush Company, he said, must have known that they could not sell the lamp, and the Hammond Company sold this Company what they conceived they had bought from the Brush Company. He had now stated very frankly what the views of the directors were. So far they had sufficient capital for their requirements; and if they undertook any large work they had an arrangement with the Hammond Company by which that Company found the capital and this Company would have the profits.

The SOLICITOR (Mr. Ince), speaking as a shareholder, strongly urged the continuance of the business of the Company. After referring to the value of the concessions possessed by them, he condemned the action of the directors of the Anglo-American Brush Company in not stating that they held the Lane-Fox license concurrently with the British Company.

The CHAIRMAN put the motion and declared it carried.

Mr. WHITELEY then demanded a poll.

The CHAIRMAN stated that, according to the Articles of Association, the demand could not be acceded to unless it were made by seven shareholders, holding in the aggregate £5,000 in the capital of the Company.

The meeting then terminated, having lasted for nearly three hours.

DEVON AND CORNWALL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

An extraordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel, on the 16th inst., "for the purpose of considering a statement which will be made by the directors of this Company, and of passing resolutions thereon." Mr. William Henry Owen presided.

The SECRETARY (Mr. F. B. Lidstone) having read the notice convening the meeting,

The CHAIRMAN read the circular which had been issued to the shareholders. It stated that the directors had been prepared for difficulties in the way of introducing the light to the public, but notwithstanding that they had used every endeavour to promote the business of the Company, they had hitherto met with little or no success. Reference was then made to their purchase of the concession granted by the Great Western Company of what the Devon Company was given to understand was, *inter alia*, the exclusive right to use the Lane-Fox lamp in Devon and Cornwall. It now appeared, however, that the vendors of the concession had no such exclusive right. Shareholders had commenced actions to recover the money they had subscribed on the ground of misrepresention in the prospectus, and one shareholder on the same ground had presented a petition for winding up the Company. The questions for consideration were (1) whether the Company should be wound up, (2) whether any, and, if so, what, steps should be taken to re-construct the Company, or whether the Company should be continued as heretofore. Continuing, the chairman said that he gave the Great Western Company credit for having been in ignorance of the error they were committing in selling to this Company that which they did not possess themselves. The directors of this Company could not have supposed that there was anything wrong, having regard to the statements placed before them by the Great Western Company and the statements published in the prospectus of the Company. He, however, thought that the Company had not been damaged by not having the exclusive right to use the Lane-Fox incandescent lamp, having regard to the requirements of the recently-passed Electric Lighting Bill, which would compel them to supply any lamp a consumer might require.

Mr. GILBERT TERRELL (solicitor), who, he said, spoke on behalf of clients representing half of the capital of the Company, contended that it would be suicidal to wind up placed as the Company was, as in that case the concession they had purchased would revert to the Great Western Company, and instead of £22,000 subscribed by the shareholders they would have divided among them about £3,000. What they had to do first was to see what steps they could take to recover the money they had paid. He doubted whether any shareholder would succeed in an action for the recovery of the money he had subscribed. He concluded by moving a resolution appointing a small committee to confer with the directors as to the management of the Company, to investigate its affairs, in particular as to the responsibility for statements contained in the prospectus of the Company, and to present a report seven days before the adjourned meeting to be held on December 23.

Mr. E. FEWINGS seconded the motion.

The CHAIRMAN stated, with regard to the question how the clause complained of could have crept into the prospectus of the Company, that no business man, after placing a matter in the hands of his solicitor, looked into the affair himself. The same solicitors—Messrs. Fussell, Pritchard, Swan, and Henderson (of Bristol)—acted for the Great Western Company and this Company—seller and buyer. He was prepared to admit that that was an irregular, though it was not an unknown proceeding. He, however, raised the question at the time, but it was of a delicate nature.

Mr. WALTER WEBB objected to the resolution. He argued that the shareholders should show the utmost confidence in the directors and so strengthen their hands.

Mr. HOWARD would oppose the appointment of a committee, and he held that they could pass no resolution whatever at that meeting.

Mr. SHEPPEY held that they should continue the business.

Lord CLAUD HAMILTON thoroughly concurred with Mr. Webb. To attempt to wind up the Company or place affairs in the hands of a committee would be suicidal. He was a director of the present Brush Company, who had sold concessions, acting, as they believed, in the interests of their shareholders. All that the present Company gave, however, was the exclusive concession for the Brush dynamo machine and arc light and a license for the full use of the Lane-Fox lamp. Knowing they could not give an exclusive right to the use of that lamp they gave a full right, making no charge for it. They sold concessions to those who wanted them, and any errors that had occurred were doubtless attributable to those who had been concerned in the formation of the sub-companies. He maintained that no fault was owing to the Brush Company. As to the practical result, however, he did not believe that 6d. loss had been sustained by the misuse of the word "exclusive." He believed that this storm in a teacup would soon be calmed. The directors should be strenuously supported.

Mr. HENRY MAUDSLAY, M. Inst. C.E., a director of this Company and of the Great Western Company, stated that the Board were under difficulties, and they asked for the co-operation of the shareholders. He thought that the Brush Company at the outset had made a great mistake in charging so largely for their articles. This he said was shown in the enormous decline in the market value of their shares. They were now acting differently. He himself had lost £4,000 by electricity, and he held 1,000 shares in this Company (£2 10s. paid), which were selling in the City at 3s. 6d. He had actually sold 100 shares in the Great Western Company (£2 10s. paid) for 10s. He then explained the circumstances of the formation of the Company, and said that the point to know was who were responsible. An investigation of the affair would not necessarily be for the winding-up of the Company. What the directors required now was the confidence of the shareholders. He admitted that the directors had committed an error.

In answer to Mr. COLLINS,

The CHAIRMAN gave an outline of the operations of the Company, with the view of showing that they would be justified in continuing the work.

Mr. TERRELL consented to withdraw his resolution, and,

At the suggestion of Mr. WEBB, a motion was submitted and approved—not as a resolution, but as an expression of the opinion of the meeting—giving its entire confidence to the Board, and desiring to strengthen its hands in continuing the business of the Company, and opposing all hostile actions against the Company, or the action thereof.

The proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES Nov. 15.		BUSINESS DONE WEEK ENDING Nov. 15. Highest.	Lowest.
Anglo-American	47¼,	48¼	49¼	48¼
Do. Preferred	78,	79	80¼	78¼
Do. Deferred	17¾,	18¼	19¼	17¾
Brazil Submarine	11¾,	12	12¼	12 1-16
Cuba	9¼,	10	—	—
Do. Preference	16,	17	—	—
Direct Spanish	6¼,	6¾	6¾	6¼
Do. Preference	15¼,	16¼	—	—
Direct United States Cable	11¼,	11¾	12	11¼
Eastern Telegraph	10¼,	10¾	10¾	10 9-16
Do. 6 per Cent. Preference	12¾,	13¼	13 3-16	13
Do. 5 per Cent. Debentures, 1899	103,	106	—	—
Eastern Extension	11⅝,	11¾	11 13-16	11¾
German Union	9¾,	10¼	—	—
Globe Telegraph and Trust Company.	6¼,	6½	6¾	6 7-16
Do. Preference	12¼,	12¾	12 13-16	12 11-16
Great Northern	12¼,	12¾	12¼	12¼
Indo-European	30½,	31¼	—	—
Mediterranean Extension	1¾,	2¼	—	—
Do. Preference	8,	9	—	—
Reuter's	12½,	13	—	—
Submarine	245,	255	253¾	252½
West India and Panama	1¼,	1½	1 7-16	1 5-16
Do. 1st Preference	7,	7½	7¼	7
Western Brazilian	7½,	7¾	7 13-16	7 9-16
West. Union 7 per Cent. 1st Mortgage	121,	124	124	124
Do. 6 per Cent. Sterling Bonds	100,	103	—	—

TELEPHONES.

Consol. Telephone and Maintenance	1,	1¼	1 3-16	1¼
Oriental	¾,	1	¾	¾
United Telephone	10¾,	11¼	10¾	10¾

ELECTRIC LIGHT.

Anglo-American Brush	11,	11½	12	9¾
Maxim-Weston	¼,	½	¼	¼
Eastern Electric	2,	2¼	2¼	2

TRAFFIC RECEIPTS FOR OCTOBER, 1882.

COMPANIES.	Oct., 1882.	Oct., 1881.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,000	2,192	—	192
Direct Spanish Telegraph Company	2,079	2,063	16	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	29,925	31,164	—	1,239
Eastern Telegraph Company	58,173	48,872	9,301	—
Great Northern Telegraph Company	21,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SLIP

SOCIETY OF ARTS.—On Wednesday evening, Dec. 13, Mr. W. H. Preece, F.R.S., will read a paper before this Society on "Electrical Exhibitions."

TELEGRAPHIC EXTENSION IN QUEENSLAND.—The Postmaster-General of this colony has promised to construct a telegraph line from Rockhampton to Port Alma.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of the Brazilian Submarine Telegraph Company for the week ended the 17th inst. amounted to £3,813.

ELECTRIC LIGHTING IN MELBOURNE.—The use of the electric light is becoming very general in many of the largest shops in Melbourne, says the *Colonies and India*.

ELECTRIC LIGHTING AT MAIDSTONE.—The Dog Show held at Maidstone last week was satisfactorily lighted up with Brush lamps by the South Eastern (Brush) Electric Light Company.

APPOINTMENT.—Mr. J. K. D. Mackenzie, A.S.T.E., has been appointed chief engineer and electrician to the Metropolitan (Brush) Electric Light and Power Company, of 110, Cannon-street, E.C.

LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY.—The revenue of this company for August is estimated at £1,694 (Western Brazilian portion £1,235, and land lines £459), against £1,813 in 1881.

EXHIBITION AT BUENOS AYRES.—According to the list of awards at this year's exhibition at Buenos Ayres, Messrs. Siemens Brothers have been awarded a gold medal for their exhibits under the head of electric lighting.

WEST INDIES.—The cable between St. Vincent and St. Lucia is repaired; that between St. Croix and Trinidad is now interrupted, and there is no telegraphic communication with Grenada, Trinidad, and British Guiana.

ROYAL SOCIETY.—At this society's meeting on Thursday last the following paper was to have been read by Mr. R. Shida, viz.:—"Experimental Determinations of Magnetic Susceptibility and of Maximum Magnetisation."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 15th November are £1,540, as compared with £2,129 in the corresponding period of 1881.

A POWDER MAGAZINE STRUCK BY LIGHTNING.—A despatch from Scutari, in Albania, dated November 17, stated that the powder magazine of the fortress at that place had been exploded by lightning. There was no loss of life.

ELECTRIC LIGHT IN LIVERPOOL.—The jewellery shop of Mr. W. L. Lawson, at 40, Lord-street, Liverpool, is now lighted by electric lamps. The lights are supplied by the Lancashire Maxim-Weston Company, of Peter's-lane, Liverpool.

ELECTRIC LIGHT IN PRINTING WORKS.—The Provincial Brush Electric Light Company have received orders to light up the extensive printing works of Messrs. Hazell, Watson, and Viney, at Aylesbury, throughout. Arc lamps will be used.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending November 17 were £2,548, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

LANCASHIRE MAXIM-WESTON COMPANY.—Mr. Thomas Ross Comyn has been appointed secretary for the Lancashire Maxim-Weston Electric Company, and the registered offices of the company have been removed to 56, New Broad-street, E.C.

ELECTRIC LIGHT FOR COLLIERIES.—The Hammond Electric Light Company have erected several Brush lamps at Birley collieries, near Sheffield, which are now in use. They are about to supplement these by a number of incandescent lamps also.

TELEPHONE WIRES IN BIRMINGHAM.—The Telephone Company in Birmingham are negotiating with the Corporation for the laying of some of their lines underground. The work will be begun by placing underground the wires now crossing Stephenson-place.

LIFE OF A MAXIM LAMP. -At the New York Post Office it has been found that the average life of a Maxim incandescent lamp (the ordinary 50 candle-power type) is nearly 1,900 hours. About 25 per cent. of the lamps in this office have burnt between 3,000 and 4,000 hours.

DIRECT SPANISH TELEGRAPH COMPANY.—This company have removed their general offices to Leadenhall-buildings, Leadenhall-street, E.C. The offices for collection, transmission, and delivery of telegrams are at No. 1, Leadenhall-street (corner of Gracechurch-street), E.C.

ELECTRIC LIGHTS IN MINES.—Electric lights are being fitted at some of the principal mines in the Furness district. Lamps are placed at an elevation over the pit heads. At Messrs. Kennedy Brothers' Ronheal Mines, the offices, workshops, and stores are illuminated by this means.

WEST COAST OF AMERICA TELEGRAPH.—The rate for messages, *viâ* Galveston and the Central and South American and West Coast of America Telegraph Company's lines, to Buenos Ayres has been fixed at 16s. 4d. per word, and to all other places in the Argentine Republic at 16s. 9d. per word.

ELECTRIC LIGHTING IN GHENT (BELGIUM).—The Edison Company in Belgium have fitted 60 incandescent lamps in the offices and works of Messrs. De Smedt and d'Hanis in Ghent. They are said to work well, and to cost less than the gas hitherto burned. Our readers must remember, however, that gas on the Continent is very dear.

ELECTRIC LIGHT ON SHIPS.—The "Malabar," Indian troopship, which is undergoing extensive overhaul and repairs at Portsmouth, is to be lighted by the electric light. The Edison incandescent system is the one selected, and the installation will be undertaken by the contractors. Each deck will be illuminated by A and B lamps.

ELECTRIC LIGHT IN COAL MINES.—Mr. Ellis Lever has offered to give a premium of £500 to any person who will invent the best portable electric lamp for use in coal mines. Mr. Burt, M.P., and Mr. W. Crawford have put themselves in communication with Mr. Lever for the purpose of rendering him their assistance in promoting the object he has in view.

DEATH.—The death is announced of Mr. Thos. B. Ascough, Postal Telegraph Department, on the 19th inst. Mr. Ascough was in the service of the Universal Private Telegraph Company previous to his transfer to that of the Post Office, and he continued to take a prominent part in the management of privates wires to the time of his decease, which occurred very suddenly.

ELECTRIC LIGHTING IN COLCHESTER.—The Corporation of Colchester have passed a resolution granting permission to

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the South Eastern (Brush) Electric Light Company to break up the streets, in order to lay their cables. The company are making preparations for lighting the High-street, Colchester, with Lane-Fox incandescent lamps, and the work will be carried out as soon as possible.

Electric Lighting in Offices.—The offices of the South Eastern and Provincial Brush Electric Light Companies at 110, Cannon-street, E.C., are both lighted by Lane-Fox incandescent lamps. The current is supplied on the B.T.K. system of storage recently introduced by these companies, and which we illustrated and described in our issue of October 28. (*Elec.*, Vol. IX., p. 560.)

To be Wound Up.—A petition for the winding up of the Great Western Electric Light and Power Company came before Mr. Justice Chitty on Saturday last. It was presented by Mr. W. H. Budgett, a merchant of Bristol, and a shareholder in the company. The Electric Gas Lighting Company and the London and Provincial Electric Gas Lighting Company are also to be wound up.

Electric Lighting in Spain.—The Anglo-Spanish (Brush) Electric Light Company will shortly have an installation of Brush lamps running in Valladolid. The authorities of San Sebastian, where this company have been lighting several streets with similar lamps for the past three months, are so satisfied with the performances of the system that they have taken over the plant and are running it themselves.

Electric Light in Dundee.—Commercial-street, Dundee, is now lighted by five Brush lamps. The lighting is, by arrangement with the Police Commissioners, to last over one month as an experiment. The work of erecting the lamps, &c., was superintended by Mr. W. C. Martin, district electrician and manager of the Brush Company in Scotland. One of Robey's vertical engines is used to drive the dynamo machine.

Electric Lighting in Brixton.—The Standard Fyfe-Main Electric Light Company have received an order from the proprietors of the Bon Marché at Brixton to light up a portion of their extensive premises by means of twenty-four Fyfe-Main arc lamps similar to those that have been for some time in use at the *Daily Telegraph* offices in Fleet-street. The patentees claim for these lamps a power of 3,000 candles.

Lightning and Telephone Wires.—A continental paper, entitled *L'Europe*, says, with reference to the recent thunderstorms which have occurred throughout the whole of Europe, that, contrary to the opinion of some, telephone wires have in no case been a source of danger. At Brussels, Ghent, Antwerp, and elsewhere, where lightning fell with disastrous effects, the telephone lines remained intact. At Berlin again not a wire was damaged.

Electric Light at Bridgeton (Scotland).—One of Akester's patent arc lamps has been erected by the Universal Electric Company at Bridgeton Cross. Professor Jamieson, of the Glasgow College of Science and Arts, and Professor Silvanus P. Thompson, of Bristol University, are quoted as authorities for the statement that the lamp gives an illuminating power equal to 1,500 English standard candles per electrical horse-power expended.

Electric Lighting in Picture Galleries.—The Société Industrielle Belge d'Electricité has lighted up M. Vereschagin's exhibition of pictures at the Palais des Beaux Arts, Brussels, by means of 16 soleil or sun lamps. The pictures are placed in two rooms of 30 metres length each. In one of these rooms there are seven lamps, in the other six. The light is reflected on to the pictures, and is said to show them up most effectively, bringing out the colours very satisfactorily.

Electric Lighting at Kew.—The roads on the Selwyn Court Estate, between Kew and Richmond, are now lighted by Brush lamps. This estate has been divided into building lots, so that the roads will presently become streets. The South Eastern Brush Electric Light Company, who have carried out the above lighting by arc lamps, are also going to introduce incandescent lamps into the houses already built, and those about to be built. The current will be supplied on the B. T. K. system.

The Ferranti Machine.—As a good deal has been said about this dynamo machine lately, and as the most conflicting rumours are abroad concerning it, we may say that we have the best authority for stating that a Ferranti machine has been run recently with satisfactory results, and that experiments as to its efficiency, &c., are being conducted. We shall hope to be able at no distant date to publish some figures relating to these experiments, and to give some account of the machine.

Electric Light in Engineering Works.—The sixteen Brush lamps that have been in use for some little time at Hawthorn's engineering works at St. Peter's, near Newcastle-on-Tyne, have been increased to thirty-two. Messrs. Leslie, of Hebburn, who have also been using sixteen Brush lamps for some time, have had twenty-four more erected in their works, making forty lamps altogether. The plant in both cases has been supplied and erected by the Hammond Electric Light and Power Company, of Cannon-street, E.C.

Electric Intercommunication on Trains.—A good illustration of the need of this mode of intercommunication between passengers and guards was afforded on a German railway the other day whilst travelling between Lottringhausen and Hörde Stations, near Dortmund, in Westphalia. A fire broke out in a carriage of the train, the fire increased as the train progressed, and it was only by dint of much shouting that the unfortunate passengers at length attracted the attention of the guard, and were released from their perilous position.

Electric Light on a Yacht.—The new steam yacht, "Empress," recently built by Earle's Engineering and Shipbuilding Company, of Hull, and now being fitted up, will be lighted by incandescent lamps. Thirty Swans will be used, the current being supplied by a Bürgin dynamo, driven by one of Marshall and Co.'s $2\frac{1}{2}$ horse-power vertical engines. Accumulators will be provided, which will supply sufficient current to keep the lamps alight when the yacht is in harbour and the fires down. The work will be carried out and the plant supplied by Messrs. R. E. Crompton and Co.

A New Electrical Paper.—We have received a copy of *L'Elettricita*, a new paper, devoted to electrical subjects and published at Milan. The first number contains a portrait and memoir of Alexander Volta, a description of the telephone, an article on the applications of electricity, &c., and concludes with an article on electrical navigation. We notice a sentence in this article which is rather amusing. The writer is talking of steam yachts, which he says are now owned by numbers of "milord Inglesi, lords scozzesi, nobile yankees e principi russi." *L'Elettricita* begins with eight pages and an outside sheet.

Electric Lighting in a Cotton Mill.—The Kingston Cotton Mills, of Messrs. Wright, Turner, and Sons, at Pendleton, employing 700 hands, are now lighted up by the Edison system. At present two K dynamos only are running,

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these being capable of supplying current for 500 incandescent lamps of 16 candle-power; but eventually it is in contemplation to run 1,000 lamps. Two Siemens arc lamps are used to light the mill yard. The actual number of incandescent lamps in use is 540. The work has been carried out by the Edison Company, of Manchester, under the superintendence of their engineer, Mr. Ruddle.

Professor Palmieri.—The death is announced of Signor Luigi Palmieri, well known in connection with the observatory on Mount Vesuvius. Although better known as an observer of earthquake phenomena, Professor Palmieri was not unknown in the electrical world. *L'Electricité* says that we owe a simple form of electrometer to him, constructed on the same principle as that of Pelletier. He applied his instrument to the construction of an original apparatus, designed to discover the frauds perpetrated by the vendors of olive oil in Italy. M. Palmieri, our contemporary says, had peculiar ideas as to the production of electricity. He thought that the condensation of the vapour of water disengaged large quantities of it.

Magnetic Observations.—A series of magnetic observations, which are to extend over the space of fourteen months, have recently been commenced at Goettingen, Germany. They will take place under the supervision of the Professor of the University on the 1st and 15th of every month, at the same hours as those performed by the international expeditions sent out to the North and South Poles. Their principal object is to ascertain the magnetic condition of the earth. Experiments will also be made with respect to magnetic intensity in the garden of the observatory, in a pavilion built up of wood and brick only, iron being omitted on account of the disturbing influences which it would exert, rendering the observations practically valueless.

Electric Light in Factories.—A portion of the lace finishing works of Messrs. Copestake, Hughes, Crampton, and Co., at Nottingham, have for some time past been lighted by 16 Brush lamps. The light given by this system has been so much appreciated by the *employés* and the firm that they have determined to introduce incandescent lamps into their rooms as well. Between 100 and 200 Swan lamps will, therefore, shortly be fitted up. The work required to be done by the hands is very fine and necessitates plenty of light, which must also be of good quality. The change from gas to electric light, so far as it has been tried at present, has been a great boon to the workpeople, affording, as it does, a purer atmosphere for them to work in. The lamps and machinery have been erected by the Hammond Electric Light and Power Company.

Transmission of Power to a Distance.—In a note on the subject of M. Marcel Deprez's experiments at Munich, our contemporary, *La Révue Industrielle*, says:—"The return of 60 per cent. quoted by M. Deprez (see *Electrician* of Nov. 4th, p. 589) was purely electrical, whilst the useful (*industriel*) return, that is to say the ratio, of useful work (measured on the brake at Munich) to work expended (measured on the dynamometer at Miesbach) was 30 per cent. at the most, or barely a half. The result, therefore, as announced to M. Deprez by the Committee at Munich, is that the 'electrical return measured varied from 50 to 60 per cent., whilst the useful return (*rendement industriel*) ranged from 25 per cent. in the first experiment (the generator making 1,000 revolutions) to more than 35 per cent. in the second one (the generator making 2,000 revolutions).'"

Provisional Orders.—The Provincial (Brush) Electric Light Company have given notice of their intention to apply for powers to supply electricity for lighting and other purposes in the following towns:—Bury St. Edmunds (Suffolk), Norwich, Luton (Beds.), High Wycombe (Bucks.), Lowestoft (Suffolk), Great Yarmouth (Norfolk and Suffolk), Bedford, Cambridge, and Ipswich. The SouthEastern (Brush) Electric Light Company have given similar notices with reference to Gravesend, Folkestone, Maidstone, Canterbury, Margate, Rochester, and Chatham, all in the county of Kent; Richmond and Croydon, in Surrey; and Colchester, in Essex. The Corporations of Warrington and Heywood, in Lancashire, and Swansea, in Glamorganshire, have also given similar notices as regards their boroughs. The notice of the Heywood Corporation refers, however, to powers to provide and maintain telegraphic and telephonic communication, in addition to electric lighting, &c. The Southend (Essex) Local Board have likewise given notice that they will apply for a provisional order.

The Telegraph in France.—The *Standard's* Paris correspondent wrote on Monday last as follows:—"An ill-considered attempt by a Radical member, M. Maret, to reduce the estimates for the Post and Telegraph Department, which M. Cochery has converted from a burden into a source of revenue, was defeated by the huge majority of four hundred and fifty-six to fourteen. M. Cochery is the Rowland Hill of France, and something more. M. Cochery, since he took in hand the management of the Postal and Telegraphic Service, has worked wonders. He has reduced the tariff for inland telegrams to five centimes (one halfpenny) per word, and that he has not effected equal reductions in the international tariff is solely due to the fact that his hands were tied by previous treaties and monopolies. It is due to him that telegraphic communication in France is cheaper and more rapid than it is in England or the United States. All who are compelled to use frequently the Postal and Telegraph Service, and who remember what it used to be, feel bound to acknowledge how much they are indebted to M. Cochery for facilitating their work. The estimates were carried *nem. con.*"

Electric Lighting on the Stage.—It appears that the letter from "A. I. C. E." to *The Times*, in which the writer descanted on the danger of allowing ballet girls to carry about electric lamps attached to their person, and which we noticed on page 4 of our last issue, was prompted by a paragraph, stating that the chorus ladies at the Savoy Theatre, who are to represent fairies in a new opera which is to be brought out there, are to wear Swan incandescent lamps in their hair. The conducting wires are to be covered with silk of the same colour as the ladies' dresses in order to render them less conspicuous. "A. I. C. E." is allowed by *The Times* to take his text from this subject, and preach a sermon on the iniquity of allowing theatrical managers thus to trifle with the lives of their "supers." We have no hesitation in saying that the danger incurred by the chorus ladies in question is so infinitesimal as practically to amount to none at all. "A. I. C. E." ought to know this, if he knows anything about electric lighting. If he does not, then he ought not to rush into print and talk nonsense. Above all, how is it *The Times* finds a place for such letters as that from "A.I.C.E?" We have referred to this matter in our leading article.

The Danger of Overhead Wires Illustrated.—A daily paper of Saturday last says:—"The dangers attending the fixing of telegraph and telephone wires on the top of buildings was yesterday (Friday) demonstrated in Manchester in an alarming manner. Shortly after one o'clock the large warehouse of Messrs. George Hodgkinson and Sons, quilt and counterpane manufacturers and packers, at Manchester, was totally destroyed

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by fire, and a loss of probably £100,000 incurred. The warehouse was in the centre of the business portion of Manchester, and, with the exception of the Royal Exchange, was the most important centre of overhead wires in the city. Fully 300 wires converged on the building or passed over it, and were in the midst of the fire. A few of them broke soon after the fire had heated them, and fell into the street. The main portion held out until the roof of the warehouse fell in, and they were then broken by hundreds, and the ends of most of them fell in a state of white heat into the streets or on to the roofs of the adjoining buildings. The whole of the telegraphic and telephonic communication with the most important portion of the city was absolutely destroyed. The Mayor of Manchester (Mr. Alderman Hopkinson) and the chief officials of the Lancashire and Cheshire Telephonic Company and the Postal and other telegraphic companies were present at the fire immediately afterwards, considering the best means of restoring the communication; but some considerable time must elapse before that can be done. The hanging wires were a source of great danger for the time being. An agitation has been progressing for some time in favour of the Corporation compelling all electric communication to be made by underground wires."

Legal—The Telephone Case.—In the High Court of Justice, Chancery Division, on the 17th inst., before Mr. Justice Fry, the case of the United Telephone Company *v.* Orme and Co. came on again. This was an action for infringement of the Bell patents, but on the delivery of the statement of claim the defendants consented to judgment being given against them on certain terms agreed upon.—Mr. Moulton appeared for the company.—Mr. Williamson had been instructed by the defendants to express great regret for the infringement, to apologise to the plaintiffs, and to express gratitude for the generous leniency shown to them by the arrangement made.—Judgment was accordingly given against the defendants by consent.—On the same day the cases of the United Company *v.* Butler, and the same *v.* Haines, also came on. The first of these two actions had reference also to the Bell instruments. The defendant had been served with notice, but did not appear.—Mr. Justice Fry granted an injunction, with costs, in the terms of the relief prayed, ordered the defendant to deliver up all telephones and telephonic apparatus in his possession which infringed the patents, and directed an inquiry as to damages. The second was a similar case, with the exception that it sought to restrain the infringement of Edison's instruments, as to which, in the action against Harrison Cox-Walker and Company, his lordship, while holding that the claim with regard to the telephone was good, felt himself precluded from giving judgment for the plaintiffs upon it because of their failure to make good their case in regard to the phonograph That part of the claim rejected by the judgment, so far as the Edison instruments were concerned, had, however, been since got rid of by disclaimer, and his lordship now made a similar order to that made in Butler's case, except that it applied to both patents.

Local Authorities and the Electric Lighting Act.—The following resolution was passed at an adjourned conference of local authorities, held at the Grand Hotel, Birmingham, last week:—"After hearing the report of the deputation to the Board of Trade, and considering the position of local authorities both as regards the interest of the ratepayers in the event of such authorities themselves working the electric light, and in the event of its being worked by trading companies, this conference is of opinion that the science of lighting by electricity is not yet sufficiently developed to justify local authorities expending the ratepayers' moneys in becoming undertakers for the supply of the light; but that every facility should be given by local authorities to trading companies to enable them to develop and work the discovery, and that local authorities should content themselves by making proper provisions for the protection of the ratepayers in regard to the following, amongst other points:—1. Retaining full control of the streets. 2. Suitable situation of the works, so as to secure freedom from danger, nuisance, or annoyance to the inhabitants in the immediate neighbourhood. 3. Regulations as to the wires and lamps, so as to secure freedom from danger. 4. Supply at reasonable prices. 5. The right of purchase by the authorities from the undertakers at a shorter period, if possible, than that provided for by the Act. 6. To endeavour to limit the area over which provisional orders are granted, so as to confine it within such reasonable limits as will enable the local authority to purchase the undertaking with facility, and not have cast upon the ratepayers the burden of purchasing the monopoly over a large and extended area, and also so as to permit co-existent experiments to be made by other companies in other parts of the districts, providing an authority decides to concur in the grant of provisional orders to competing companies. 7. To secure from time to time on the board of management of the electric lighting company direct representation for the ratepayers, by stipulating that at least two members of the local authority shall be *ex-officio* members of such board of management."

Electric Lighting in the Country.—The Association of Municipal Corporations held a meeting a few days since, and came to the conclusion that it was expedient that corporations should take a general course of action with reference to the proceedings under the Act. The Corporation of Oldham, having sought the advice of Mr. Shoolbred, electrical engineer, this gentleman recommended them to select a small district in which to make an experimental trial of incandescent lighting. A district has been selected in accordance with this recommendation, and Mr. Shoolbred has been instructed to make an inspection thereof, and report on the probable cost of erecting and laying down the plant. It is intended, we believe, to begin with about 10,000 incandescent lamps. Batley (Yorks.) Town Council have resolved to apply for a provisional order. Leamington (Warwick) Town Council have adopted a similar course, and in making a recent contract with the gas company reserved the right to light by means of electricity three of the principal streets in the town. Aston (Birmingham) Local Board will not apply for a provisional order, but will open negotiations with one or more electric light companies to supply electricity for lighting purposes, the board retaining full control of the streets, &c. Birkenhead Town Council will apply for an order, and do not seem to look with a favourable eye on outside companies. Darlington Town Council own the gasworks, and consequently do not like other light supplying companies in the town. They will, therefore, apply for an order. Saltley (near Birmingham) Local Board, like Aston, will not apply for an order themselves, as they do not think that the ratepayers' money should be spent in "becoming undertakers for the supply of electric light." They, will, however, give every facility to electric light companies, proper regulations being introduced with regard to breaking up streets, &c. Balsall Heath Local Board (also near Birmingham) are of the same mind as Saltley and Aston. The Leek (Staffs.) Improvement Commissioners will not commit themselves to any course at present, but will "watch the progress of events." Tunstall

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(Staffs.) Local Board will apply for an order, and oppose outside companies. The Wednesbury (Staffs.) Local Board have agreed "to leave the lighting of the town to private enterprise."

THE TELEPHONE IN FRANCE.—The following are some telephonic statistics for the week ending November 15 last, issued by the Société Générale des Téléphones of Paris:—The number of subscribers to the Paris exchange of this company on November 8 was 2,521, during the week they gained 28 and lost 10, leaving them on the 15th with 2,539. On the same date in 1881 the number was 1,933. The number of subscribers connected up to the same exchange on November 8 was 2,275, 17 more were connected up during the week ending November 15, and 11 were disconnected, leaving them with 2,281 subscribers connected up, the number at same date in 1881 being 1,330. The exchange has 152 auxiliary lines, consequently the total number of their lines on November 15 was 2,433. The number of direct communications between subscribers was 63,362, by auxiliary lines 56,392, making a total of 119,794. During the corresponding week of 1881 the figures were 98,717. In Bordeaux on November 8 the company had 233 subscribers. This was increased by 2 during the week, leaving them with 235 on the 15th inst., against 138 at the same date in 1881. On the same date they had 221 subscribers connected up, and 6 were connected during the week, making, on the 15th inst., 227, against 103 in 1881. The number of direct communications between subscribers was 4,505 during the week, against 825 in 1881, a marked increase. On November 8 the company's Havre exchange numbered 165 subscribers, against 99 in in 1881. On November 8 there were 151 subscribers connected up, against 68 last year. The total number of direct communications between subscribers to this exchange during the week ended the 15th inst. was 2,855, in 1881 it was 1,462. At Lille, the company had, on the 8th inst., 115 subscribers, against 32 in 1881. Of these, 86 were connected up on the 8th inst. The number of direct communications between subscribers was 825. At Lyons, on the same date, their subscribers numbered 374, and they gained 2 before the 15th inst., making the total 376. In 1881, it was 211. They had 345 subscribers connected up on the 8th, and on the 15th 347, against 174 last year. The number of direct communications between subscribers was 20,733, while at the same date in 1881 it was 7,726. The Marseilles exchange had 244 subscribers on the 8th inst. This was increased to 248 before the 15th inst., against 142 last year. Two hundred and thirty-one were connected up on the 8th, and 233 by the 15th, against 134 in 1881. The number of direct communications was 9,551, in 1881 it was 2,092. At the same date the Nantes exchange had 100 subscribers, and Rouen 52. Neither of these gained any during the week. Nantes had only 67 subscribers in 1881 and Rouen none. On the 8th inst. Nantes had 79 subscribers connected, and Rouen none. The number of direct communications at Nantes during the week was 1,116, against 821 in 1881. The total number of subscribers to the company's exchanges on November 8 was 3,804, they gained 36 during the week and lost 10, leaving them with 3,830, against 2,623 in 1881. The number connected up on November 8 was 2,388, 27 were added during the week, and 11 disconnected, leaving a total of 3,404 connected up, against 1,871 last year. The number of direct communications between subscribers over the company's lines during the week ended November 15 was 102,947, and by auxiliary lines 56,392, making a total of 159,339, against 71,643 in 1881.

ELECTRIC LIGHTING IN THE CITY.—On Tuesday last, at a special meeting of the City Commissioners of Sewers, held at Guildhall, Mr. Felton presiding, a report was brought up from the Streets Committee by Mr. Pannell, their chairman, in regard to the notices from various electric lighting companies of their intention to apply to the Board of Trade under the Act of 1882 to enable them to light the City by electricity. The committee instructed Colonel Heywood, the engineer, to obtain the opinion of some eminent electrician as to whether it would be practicable to lay in the same tube the conductors of various companies for lighting by different systems of electricity without the conductors so laid injuriously interfering with each other, and also whether the conductors laid in a district by any one company could, if their usage by that company be discontinued, be made available for any other company using a different system. They now submitted a long report from Mr. W. H. Preece, of the General Post Office, on these points. His opinion was that, except in a subway of considerable size, it was impracticable to maintain the conductors of different companies in the same tube. As to the other point, he observed that the arrangement of conductors to fulfil the requirements of an electric light system was a very complicated matter indeed, and he knew of no branch of engineering where more forethought was necessary to calculate all the contingencies likely to be met with than a system designed to illuminate a large city like London. Every system required its own distribution, dependent upon the area to be illuminated, the number of lights, the route of the conductors, and the position of the generating station. The whole question of the distribution of electricity for lighting purposes was in a very tentative state. Sufficient experience had not yet been gained to determine exactly what was required in all circumstances, or even what those circumstances would be, and he thought that those corporations who had taken on themselves to supply electricity had undertaken a responsibility that they had not sufficiently contemplated, and which, with the present state of our knowledge, was extremely difficult to discharge. Hence, he said, that while there might be cases where the conductors of one company might be available for another, there could not be a case where they were properly available unless the two companies employed the same system and utilised the same central station for the generation of their electricity and the distribution of their force.—Mr. J. V. Moore moved, and Mr. Boor seconded, "That the Remembrancer be instructed to take all necessary steps to enable the Commission to become the undertakers for the supply of electricity to the City under the provisions of the Electric Lighting Act, 1882; to obtain a provisional order under the regulations laid down by the Board of Trade, and to oppose the applications of all other parties." To that Mr. Innes moved, and Mr. Baptie seconded, as an amendment, "That while the Commission was in favour of electric lighting in the abstract, it was advisable to allow all further experiments to be conducted at the risk of the lighting companies, and not at the expense of the ratepayers." After a discussion lasting some hours, the amendment was carried by 31 votes to 26, and subsequently, on its becoming the substantive motion, by 22 votes to 21. It was then further resolved, at the instance of Mr. Alderman Staples, that the Remembrancer be instructed to appear, on the application of the electric lighting companies, and secure clauses protecting public and private rights. Mr. Stoneham gave notice of motion for the appointment of a Select Committee to inquire into the steps to be taken to enable the Commission to be the undertakers for the supply of electricity, looking at the vast interests at stake.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XX.

E.M.F. Generated in a Modern Siemens Armature, made without Iron, and Rotating in a Uniform Magnetic Field.

Let each coil consist of K turns of wire, enclosing each a mean effective area A.

Let there be $2c$ such coils wound on the drum in pairs, as in Figs. 5—11 of the last article, the coils in each pair being close together, and the angles between successive pairs being $\frac{\pi}{c}$ or β.

Let the drum be rotated in a magnetic field, F, with angular velocity ϵ.

Then the E.M.F. in each coil at any time t is, see Art. XIV.,

$$K A F \epsilon \sin(\epsilon t + a)$$

where the phase a has values differing by β for successive coils.

The total E.M.F. in the armature is the sum of all the E.M.F.'s generated in the c coils in series, and is therefore

$$E = K A F \epsilon \{ \sin \epsilon t + \sin(\epsilon t + \beta) + \sin(\epsilon t + 2\beta) + \ldots\ldots + \sin\big(\epsilon t + (c-1)\beta\big) \}$$

$$= K A F \epsilon \frac{\cos(\epsilon t - \frac{1}{2}\beta)}{\sin \frac{1}{2}\beta} \quad \ldots\ldots\ldots \quad (1)$$

Now, if t is allowed to increase as much as it likes, this will represent a mere periodic function, which oscillates between the values $\pm \frac{K A F \epsilon}{\sin \frac{1}{2}\beta}$ in a period $\frac{2\pi}{\epsilon}$.

But then this is leaving altogether out of account the effect of the commutator, and it is just what would happen if the brushes of the machine rotated with the commutator so as always to rest on the same segment of it; or, what is easier to imagine, if the armature and brushes stood still while the magnetic field rotated.

But in the actual state of things the armature alone rotates, and it has only to turn through an angle β or $\frac{\pi}{c}$ for the brushes to rest on a new segment of the commutator, thereby making a fresh coil take the old one's place, and everything to start afresh.

This condition can easily be imposed upon the above formula by informing t that it can only be permitted to increase through $\frac{\beta}{\epsilon}$, and must then begin again at its former value, and so on.

This will cause the expression to be a quivering function of the time, with its variations exceedingly rapid, but almost insignificant in amount. It has its maximum value when $\epsilon t = \frac{1}{2}\beta$, and this maximum value is $K A F \epsilon \operatorname{cosec} \frac{1}{2}\beta$.

The brushes should be set so as to get the benefit of this maximum E M F, which they will do best if they are then touching the middle of a segment; and the variations in the current will then be less than if they are set in a less symmetrical position.

But now there is this very important thing to be noticed about these quiverings, viz., that unless the value of E, when the brush leaves one commutator segment, is the same as the value of E when it enters the next, there will be a discontinuity in the current and consequent sparking.

We saw in Art. XVIII. that with the Brush commutator there was always some sparking necessary, but this is not the case with the Siemens or Gramme machines; it may be possible in these so to set the brushes that the value of E with which they leave one pair of segments is the same as that with which they enter on the next.

Assuming that the brushes are always opposite to one another, but that instead of being set along the maximum line they are set an angle θ in advance, we shall have the initial E.M.F., when the brush first touches a segment, given by adding θ to the expression inside the brackets of (1), and by putting $\epsilon t = o$, or

$$E_1 = K A F \epsilon \frac{\cos(\theta - \frac{1}{2}\beta)}{\sin \frac{1}{2}\beta};$$

and the value when the brush leaves it, by putting $\epsilon t = \beta$,

$$E_2 = K A F \epsilon \frac{\cos(\theta + \frac{1}{2}\beta)}{\sin \frac{1}{2}\beta}.$$

Then when it enters on the next segment it becomes E_1 again, and so on; changing steadily down from E_1 to E_2 during the passage of a segment past the brush, but jumping suddenly up again from E_2 to E_1 as the brush crosses the gap to the next segment. And a jump like this is necessarily accompanied by extra current sparks, which waste power and burn the brushes and commutator. To avoid this discontinuity we must set the brushes so that $\theta = o$, *i.e.*, so that they are along the line giving the maximum E M F. Then putting $\epsilon t = 0$, we get the initial E.M.F. as a segment first reaches the brush, viz.:—

$$K A F \epsilon \cot \tfrac{1}{2}\beta \quad \ldots\ldots \quad (2)$$

This rises to a maximum as the brush comes on to the middle of a segment, viz., when $\epsilon t = \frac{1}{2}\beta$, being then—

$$K A F \epsilon \operatorname{cosec} \tfrac{1}{2}\beta \quad \ldots\ldots \quad (3)$$

and it then diminishes till the brush leaves the segment ($\epsilon t = \beta$), being then the same as it was at first, viz.:—

$$K A F \epsilon \cot \tfrac{1}{2}\beta,$$

and ready to pass on to the next segment without discontinuity or sparking.

Under these circumstances, therefore, the E.M.F. quivers between a maximum and a minimum value $2c$ times in a revolution, or $\frac{\epsilon}{\beta}$ times a second; the maximum value being inversely proportioned to the sine, and the minimum being inversely proportioned to the tangent, of the small angle $\frac{1}{2}\beta$ or $\frac{\pi}{2c}$. The ratio of the minimum to the maximum value is $\cos\frac{\pi}{2c}$, and remembering that c is the number of pairs of coils on the armature, and that this is seldom less than 12 or 16, while in the common Z Edison it is 72, we perceive that the variation is very small; and that it may in fact be neglected. We can, therefore, in all cases where c is reasonably large, write $\frac{2c}{\pi}$ instead of either cosec or cot $\frac{1}{2}\beta$; and so the E.M.F. is simply

$$E = \frac{2c}{\pi} K A F \epsilon,$$

or if the number of revolutions per second is n, and since $\epsilon = 2\pi n$,

$$E = 4 n c K A F \quad \ldots\ldots \quad (4).$$

Resistance of the Wire on the Armature.

The resistance of the armature may also be recorded. If r_1 is the resistance of unit length of wire used, and if the armature is μ times as long as it is broad, then since the current has to flow through c coils in series and 2 abreast, the length of each turn of wire being $2(\mu + 1)\sqrt{\left(\frac{A}{\mu}\right)}$, the resistance from brush to brush is

$$R = c K r_1 (\mu + 1) \sqrt{\left(\frac{A}{\mu}\right)} \quad \ldots \quad (5).$$

This shows that the best value of μ is 1, or that the armature ought to be as broad as long. It is, indeed, obvious that to get the greatest area with a given length of wire the best shape is a circular coil, and that the square is the best form of rectangle; nevertheless, it is frequently asserted that a Siemens armature should be long in proportion to its breadth, from some mistaken idea that the longitudinal portion of the coil is the useful, and the end wires the useless part. The real advantage of making the armature long and

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narrow is to make the gap in the magnetic circuit (the distance between the pole pieces) as short as possible. Hence the more soft iron the armature contains, the squarer may its longitudinal section advantageously be.

Hypothetical Case.

It may be useful to take a numerical example of the E.M.F. and resistance of a suppositious armature. Let the commutator have 24 segments, the armature being wound with 12 pairs of coils. Let each coil consist of 10 strands of wire in series. Let the length of the armature be 16 inches, and its diameter be 8 inches, so that the mean effective area A is about 800 square centimetres if it contain no iron.

As to the strength of the field F, the earth would only give ·47, permanent magnets might easily make it 100 units strong, and with an electro-magnet it might be got up to 1,000. Let us suppose it is 1,000.

The speed we may put as 1,000 revolutions a minute, which will make $\epsilon = 105$.

The maximum value of the E.M.F. when the brushes rest on the middle of a segment is, by equation (3),

$$10 \times 800 \times 1{,}000 \times 105 \operatorname{cosec} \frac{\pi}{24} \text{ absolute units,}$$

or, as $\operatorname{cosec} \frac{\pi}{24} = \frac{1}{\sin 7^{\circ}\cdot 5} = 7\cdot 66$, and as 10^8 units $= 1$ volt,

$$\text{max. } E = 64\cdot 34 \text{ volts.}$$

The value of cot $7\frac{1}{2}$ is 7·60, and hence, if the brushes are properly set, the value of the E.M.F. as they enter or leave a segment is, by equation (2),

$$\text{min. } E = 63\cdot 84 \text{ volts,}$$

and it will have to oscillate from one of these values to the other and back again 24 times in a revolution, or 400 times a second. As a matter of fact this is almost too rapid for the above change, though it is but half a volt, to take place completely. Moreover, we have been assuming the magnetic field uniform, but if the poles are curved round the armature so as to make each coil cut the lines of force normally as far as it can, we shall get still further uniformity, and nearly all the coils will be more decidedly assisting the action; in other words, the semi-neutral region will be diminished.

To find the resistance of such an armature, suppose the wire on it is No. 14 B.W.G., which has a resistance of 1·5 ohm per 1,000 feet about, or 20,000 centimetres to the ohm, then, by equation (5),

$$R = \frac{12 \times 10 \times 3}{20{,}000} \sqrt{\left(\frac{800}{2}\right)} = \cdot 36 \text{ ohm.}$$

NOTE.—Fig. 12 of last article was intentionally erroneous, and it would have been better so to label it to avoid misunderstanding.

THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 522, VOL. IX.)

If the battery is entirely insulated, and has no wire connected to either pole, and is also equidistant at each part from surrounding objects, and could be so charged with its liquid that its electromotive force shall come into action without any part of the battery being even for an instant in communication with external objects, then the potential at one pole will be positive and of a potential equal to half the electromotive force of the whole battery, whilst the other pole will be negative and of a potential equal also to half the electromotive force of the battery. The figure will then take the form shown in Fig. 24, A B representing the axis or line of potential equal to zero.

If either pole be touched with any object that can become charged, that pole will lose electricity, and the datum line will move up or down, according to which pole is touched, but always towards such pole and parallel to itself. If one pole is touched to earth, then the datum line will pass through that pole. Thus, if the negative pole is touched to earth the figure will become as in Fig. 25, and if the positive pole is touched the reverse figure below the datum line will occur, the negative pole obtaining a negative potential equal to the whole electromotive force of the battery.

If two bodies of unequal electrostatic capacity are attached to the poles, then the datum line will adjust itself in such a

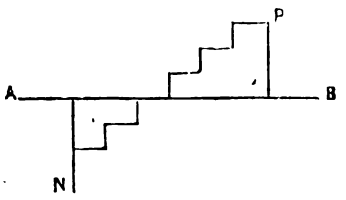

FIG. 24.

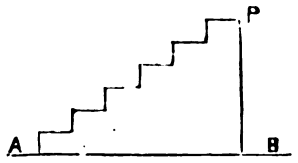

FIG. 25.

way that the quantities of electricity on each body and on a portion of the battery connected to it shall equal the quantity of electricity on the other body and on the remainder of the battery. Neglecting, for simplicity, the quantity on the battery itself, if we suppose two unequal lengths of submarine cable of similar pattern, with insulated ends attached to the two poles of a battery previously insulated at both poles before charging, then the datum line will so adjust itself that the two charges shall be equal in quantity, the length of one multiplied by the potential of the pole

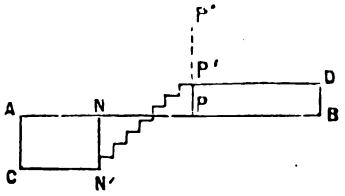

FIG. 26.

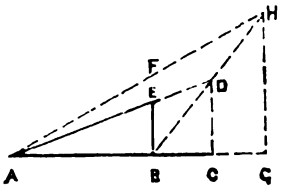

FIG. 27.

attached to it being equal to the length of the other multiplied by the potential of the pole attached to it.

Thus, if in Fig. 26, N P is resistance of battery and P P′ the electromotive force of the battery, then if a wire of equal electrostatic capacity per unit of section throughout and of a length represented by P B be attached to the positive pole P, and a length represented by A N of similar wire equal, say to half, P B, be attached to the negative pole, then the potential at P will sink to such a potential, P P″, and the negative potential at N to such a potential, N N″, that the

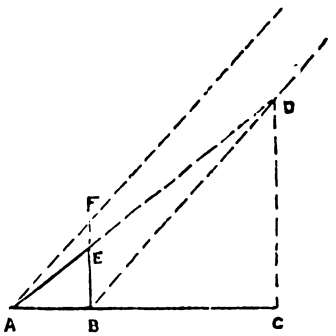

FIG. 28.

parallelogram A N N″ C, representing the charge in the wire A N, shall equal the parallelogram P P″ D B, representing the charge in the wire P B. I shall deal with the problem of insulated wires attached to the poles of an insulated battery again further on, when dealing with "inductive circuits," as there are some interesting facts connected with the subject which I have hitherto only briefly alluded to in a number of *The Electrician* some four years ago. Enough has now been given to show the general action, if I may use the term, which

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takes place with a battery when either one or both poles are insulated.

Turning again to problems of current, electromotive force, and resistance in a circuit, let A B (Fig. 27) be the external resistance of a circuit to earth at A, B C the resistance of the battery to earth at C, and C D the electromotive force, then joining D E will give B E as the potential at the battery pole attached to the external resistance, and $\frac{B\,E}{A\,B}$ is the current. Suppose now we wish to increase the current in A B to one half as much again, and wish to see how to do it. Increasing potential at B to B F = $1\frac{1}{2}$ times B E, join A F and produce indefinitely. Join B D and produce it till, if it *converges* towards A F prolonged, it meets that line at H. Then dropping H C perpendicular to A B C prolonged until it cuts at G. Then B G will be the resistance of the new battery of similar elements to B C in terms of whatever number were contained in B C, which must be employed to produce the new current, and G H will be its electromotive force. Thus, if B C contained 10 elements and B G is 2·2 times B C, then the total number required will be 22.

If, however, the resistance of the external conductor A B is small compared to the resistance of the battery, then it may happen that the lines A F and B D may be parallel, indicating, as will be seen by Fig. 28, that no increase of the same elements in series can obtain the desired current. Or they may actually diverge, which would represent also that no increase of elements could obtain the desired current. Finally, they may converge, but so slightly that they will only meet after very great prolongation, which would show that an enormous increase of elements would be required in series to obtain the desired current. In such case the desired current can only be obtained by reducing the internal resistance of the battery.

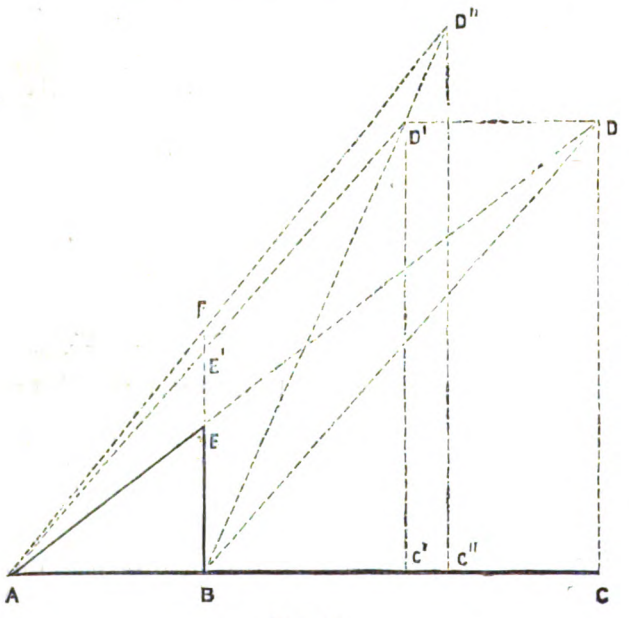

Fig. 29.

Thus, if A B (Fig. 29), as before, represent the external resistance, B C the battery resistance, and C D the electromotive force, it will be seen that A F produced and B D produced cannot meet, indicating that no increase of battery in series can produce the desired current. If we were to double the size of the plates or use the same number of double elements, the resistance of the battery would be halved whilst still preserving the same electromotive force as before, and, halving B C at C′ and making C′ D′ = C D, and joining D′ A, we should get A E′ as the line of potential. This falls within A F, and we have not yet, therefore, obtained our object. But now, joining B D′ and prolonging it till we cut A F prolonged at D″, and dropping the perpendicular D″ C″, we get B C″ as the resistance of the battery required, and consequently the number of the cells of reduced resistance in terms of whatever number were contained in B C′.

THE RELATIONS BETWEEN MAGNETIC FORCE AND ELECTRIC CURRENT.—II.

BY OLIVER HEAVISIDE.

In the preceding article bearing the above title, the meaning of the "curl" of a vector was explained and illustrated in the case of a steady current in a long straight wire. Also, from that solution were derived, by the operation of curling, the distributions of current corresponding to other possible arrangements of magnetic force. We now come to some other properties of magnetic force and current, and more generally of any similarly related vector quantities. To fix ideas, let B be a possible distribution of magnetic force, and C the corresponding electric current. We know that $C = \frac{1}{4\pi}$ curl B, and we may similarly find the curl of C, which we may call D. Thus,

$$\left.\begin{aligned} B &= \text{magnetic force, given.} \\ C &= \frac{1}{4\pi}\text{curl } B = \text{current} \\ D &= \text{curl } C \end{aligned}\right\} \text{deduced.}$$

Supposing, however, that it is the current distribution that is given, how shall we find the magnetic force? Considering the fundamental relation only, that by finding the line-integral of B once *round* any axis we get $4\pi \times$ current-component *along* that axis, if we reverse the operation we discover at once that it fails to work in a suitable manner. We do indeed know from the given value and direction of the current at a given place what the line-integral of magnetic force round it is, but that does not tell us the magnetic force at different points along the line of integration. Some other method is, therefore, wanted.

There are different ways of obtaining the magnetic force from the current. We shall commence with that one of them which has the advantage of telling us immediately in a great many cases the general nature of the magnetic force. This method is expressed in the following statement. The magnetic force is the vector-potential of the curl of the current. Here we introduce another conception, that of the potential of a vector quantity, and in order to render it intelligible, some explanation becomes necessary.

The meaning of potential in electrostatics is well known, therefore we need here merely remind the reader that the potential of a charge e at distance r therefrom is $\frac{e}{r}$, where we suppose e to be at a point, or, at least, within a very small space surrounding the point from which r is measured. It is the work that must be done to bring a unit charge from an infinite distance to the place considered. For the electric force is by definition $\frac{e}{r^2}$, and the work done in bringing a unit charge from distance r_2 to distance r_1 from e is mean force × distance

$$= \frac{e}{r_1 r_2} \times (r_2 - r_1) = \frac{e}{r_1} - \frac{e}{r_2};$$

and when the distance r_2 is infinite, the work becomes simply $\frac{e}{r_1}$. The potential of any system of free electricity is the sum of the potentials of the elementary charges into which it may be divided, and we may write it

$$\Sigma\frac{e}{r} = \frac{e_1}{r_1} + \frac{e_2}{r_2} + \frac{e_3}{r_3} + \ldots$$

$e_1, e_2, \ldots$ being the charges, and $r_1, r_2, \ldots$ their distances from the point where the potential is to be found. The electric force in any direction is the rate of decrease of the potential in that direction. But we may also consider it as the sum of the forces due to the elementary charges, or $\Sigma\frac{e}{r^2}$, where, however, we must, since force is a vector, not simply add the numerical values of the forces together, but make the proper allowance for their being in different directions; that is to say, we must find their resultant. This is

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most conveniently expressed by saying that we find the vector sum of the separate forces.

Now, in finding the potential of a vector quantity, such as current, we add together the potentials of the elements into which the current-system may be divided, *i.e.*, we find $\Sigma \frac{C}{r}$, but we must do it exactly as in the last-mentioned case of electric force, find the vector sum. Free electricity is scalar or directionless, and so is its potential, therefore simple addition of the numerical values of the potentials of the elements gives the value of the whole potential, and there is nothing else to consider. But if, for example, one current-element, C, is directed from right to left, and another equal one from left to right, the sum of their potentials at a given point is the difference of their separate potentials, and is directed parallel to the greater.

In certain cases, however the process is simplified. In a straight current, for example, the current-elements all point the same way; the potential of any element, C, at a point distant r, is $\frac{C}{r}$ parallel to C; every element of the total potential is parallel to C, and so is the total potential, and its value is the scalar sum of the potentials of the elements. We should therefore find the potential exactly as for free electricity occupying the same space as the current, and then make it a vector by giving it direction parallel to the current. Thus the potential of a system of parallel straight currents at any point is a vector drawn from that point parallel to the current; and, in general, the potential of one vector-system is another vector-system. To distinguish it from ordinary scalar-potential it is called the vector-potential. In the same way as we represent systems of magnetic force or current by means of lines, we may represent their vector-potentials by systems of lines, the direction of a line showing that of the vector-potential, and the density of the lines its magnitude at any place.

Thus the lines of vector-potential of a straight current are straight lines parallel to it, closely packed in the wire and near it, and falling off in density as we recede from the wire, according to the logarithm of the distance.

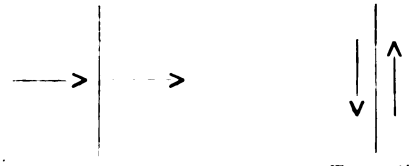
Consider next a circular current. It is easily seen, in the first place, that the vector-potential at any point, P, upon the axis of the circle is *nil*, for all the current-elements are equidistant from P, and for any element pointing one way there is just one other (at the opposite end of the diameter) pointing the other way, so that the vector-potential of one half of the circular current is annulled by that of the other half. Now, let P be no longer on the axis. It is, consequently, nearer one side of the circle than the other. The vector-potential of the nearer side preponderates, and the result is a vector at P drawn parallel to the nearest part of the circle. Let P describe a circle about the axis, parallel to the current; at every point of this circle, from symmetry, the same statement holds good, consequently the circle described by P is a line of vector-potential. Thus the lines of vector-potential of a circular current are parallel circles, centred upon the axis, closely packed in the current and close around it, and falling off in density both towards the axis in the neighbourhood of the circle, and away from it outside it.

If the current flows in a plane sheet, the current lines are closed curves in the sheet. The lines of vector-potential must be in planes parallel to the sheet, since there is no current perpendicular to it, and they are also closed curves.

In all cases we may find the vector-potential by means of three scalar sums instead of the vector sum; this is most conveniently done by forming the scalar sums of the components in three rectangular directions, and then compounding them. However convenient for calculations, this method often very much obscures the matter under consideration.

Now, we stated that the magnetic force was the vector-potential of the curl of the current. Take a straight current, for instance. As explained in the last article, the curl of the current is confined entirely to the surface of the wire, its strength is numerically equal to the current-density, and its direction is perpendicular to the current, so that the lines of the current-curl are equidistant circles on the surface, enclosing the current. From symmetry, together with the late remarks on the vector-potential of a circular current, we see that the vector-potential of the curl of the current is also in circles, in planes perpendicular to the axis, and centred thereon—that this must be the case both within and without the wire, and that they must be closely packed near the surface, and fall off in density both ways, *i.e.*, towards the axis within the wire, and from it outside. These characteristics will be readily recognised to be those of the magnetic force of a straight current.

Again, consider a current-system in a plane sheet, and derive the general nature of the magnetic force as far as we can. The current-density is supposed to be constant through the small thickness of the sheet, so that the current has no curl within the sheet and parallel thereto. But the current will in general vary from place to place in the plane of the sheet; it has, therefore, curl perpendicular to it, to be found by the line-integral of the current round a small area in its plane. This curl is a vector drawn perpendicular to the sheet, at some places it may be from the + side, at other places from the — side. Its vector-potential is the component of magnetic force perpendicular to the sheet, and we see immediately that it has the same strength and direction at corresponding points on opposite sides, and that it is continuous at the sheet itself. If *to* the sheet on one side, it is *from* the sheet at the nearest point on the other side. But besides this, there is the surface-curl of the current to be considered. As explained in the last article, it is got by turning the vector representing the current density through a right angle upon the surface. Since the sheet has two sides, we have two systems of surface-curl, both exactly alike, but oppositely directed. The lines of surface-curl intersect the current-lines at right angles. The vector-potential of this double system is the component of magnetic force parallel to the sheet. Now, on either side of the sheet, the nearer side preponderates over the other in contributing to the vector-potential, and since the surface-vectors only differ in being oppositely directed, it follows that the vector-potential is numerically the same at corresponding points on the + and — sides, but oppositely directed. Thus there is a remarkable difference between the components of magnetic force perpendicular and parallel to the sheet. The former is continuous, the latter discontinuous, as may be thus diagrammatically represented:—



Normal. Tangential.

Returning now to the general relations, it will be observed that whilst D, the curl of the current, is derived from B, the magnetic force by double curling (with division by 4π), on the other hand B is derived from D by finding its vector-potential. That is to say, the operation of finding the vector-potential is exactly annulled by double curling and division by 4π (the last operation being a question of units). Thus,

$$4\pi D = \text{curl curl potential } D.$$

This suggests that if we form a new vector, viz., the vector-potential of C, *its* curl will be the magnetic force. Thus, calling the new vector A, and at the same time introducing another vector E at the other end of the series, we have

A = vector-potential of C.

B = curl A = vector-potential of D = magnetic force.

$C = \frac{1}{4\pi}$ curl B = vector-potential of E = current.

D = curl C.

E = curl D.

Of the series, only B and C represent quantities having undoubted existence as physical realities; the rest are purely conceptions. But the last introduced quantity A,

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the vector-potential of the current, is of as much importance in electro-magnetism as the potential of free electricity is in electrostatics, being in fact its exact counterpart. D is also very useful sometimes; the rest of the possible series up or down cannot be said to be more than curiosities. A is found from the current-distribution in an analogous manner to scalar potential from free electricity, only compounding the component parts like velocities, or taking the vector sum instead of the scalar sum. And as we derive electric force from the static potential by finding the direction in which the potential decreases fastest, and the rate of its decrease, the former giving the direction and the latter the magnitude of the electric force, so we derive magnetic force from the vector-potential of the current by curling, that is, by finding the direction of the axis round which the line integral of the vector-potential is greatest, and its amount, the first being the direction of the magnetic force, the second proportional to its magnitude. This is the most usual way in electro-magnetic investigations; it does not, however, usually give so much information without calculation as the method previously described, as may be illustrated in the case of a straight current.

If we have found the vector-potential of a current-system, we know the magnetic force, viz., its curl. But it is also the vector-potential of the curl of current, so we have—

$$B = \text{curl potential } C = \text{potential curl } C.$$

Thus the two operations of curling and finding the potential are reversible, or rather commutative. This putting the cart before the horse is a slight change only in words, yet makes a vast difference when we come to carry it out, although the final result is the same.

From this commutative property we have—

$$\begin{aligned} 4\pi C &= \text{curl curl potential } C \\ &= \text{curl potential curl } C \\ &= \text{potential curl curl } C = \text{potential } E. \end{aligned}$$

As may be seen from the last list, the whole series from A to E is involved in the above, which is the expression of a characteristic property of the class of functions to which magnetic force and current belong. They have all the property of continuity which distinguishes the electric current, viz., that of flow in closed paths like an incompressible fluid. It is of the greatest assistance to conceive them as fluxes like the current, not merely as quantities having certain values at certain places. Given one of them, and then forming the others, any one of them may be taken to represent a possible system of either current or magnetic force.

The vector-potential A, for instance, of a straight current C is a flux parallel to the current, its strength proportional to $C \log \frac{a}{r}$, where a is a constant, and r the distance from the axis. Let this flux A be a system of magnetic force, its curl is the corresponding current, which must therefore be B, or the lines of current flow are exactly those of the magnetic force of a straight current.

Similarly, if we find the vector potential of B, say A_0, we know that its curl is proportional to A, so that if A_0 represent magnetic force, the corresponding current is proportional to $C \log \frac{a}{r}$. And so on.

Another way of deducing magnetic force from current will be given in a following article.

Electric Lighting in Theatres.—The Direction of the Imperial Theatres in Russia has contracted with Mr. A J. Rousseau, engineer, for the lighting of the whole of these theatres by electric lights, this system having been adopted as a precaution against fire. His Imperial Majesty the Emperor signed the concession on the 29th ultimo. Swan incandescent lamps will be used, with Bürgin machines to supply the current. There is no foundation for the statement that an American company had secured this concession.

THE ELEMENTARY PRINCIPLES OF ELECTRICITY.

I.

In these papers we propose to give such a brief sketch of the science of electricity, and of the mechanical principles on which it is founded, and in accordance with which all electrical measurements are made, as will enable the general reader to understand the system of units employed in measuring electrical quantities, and the principles upon which the actions of the various appliances employed in electric lighting depend.

At the threshold of physical science we find ourselves face to face with at least three primary conceptions, or quantities which cannot be defined in terms of anything simpler than themselves. They are time, length, and mass.

Each of these quantities, like all others, must be measured by comparison with a unit of its own kind. The unit of time invariably adopted for scientific purposes is the *second of mean solar time*.

The British unit of length is the imperial standard yard. One third of this length, or the foot, is the unit generally employed by engineers. The metric unit of length is the metre, which is subdivided into 10 decimetres, 100 centimetres, and 1,000 millimetres. The centimetre is the unit of length generally adopted by electricians. The metre is equal to 39·370432 English inches, and the centimetre is therefore equal to ·39370432 inch, or nearly ·03281 of a foot. A centimetre may be roughly regarded as about two-fifths of an inch, and a millimetre is about 1-25th of an inch.

The British unit of mass is the imperial standard pound avoirdupois. The standard itself is a mass of platinum, and is defined by the Act which gave it authority as the only standard of *weight*. It is clear, however, that the object of authorising a standard for commercial purposes is to provide a unit in terms of which quantities of material may be measured, and it is an accident that weight is generally taken advantage of for making the comparison. The pound ought, therefore, to be regarded as the unit of mass, not of weight. This is further indicated by the fact that the weight of a pound is different in different latitudes and at different altitudes, while its mass remains invariable, so that if a material standard were adopted as a unit of *weight*, that is, of *force*, it would have to be varied whenever it is moved from place to place, and would only remain the standard so long as it is kept in the same place.

The metric unit of mass is the kilogramme, but the gramme, which is one thousandth of the kilogramme, is the unit generally adopted for scientific purposes. The gramme is approximately equal to the mass of a cubic centimetre of distilled water at the temperature corresponding to its maximum density. It is equal to about 15·43234874 grains, or ·00220462121b. avoirdupois.

Every person is supposed to be provided with the requisite means for measuring time, length, and mass, and when the measurement of any other physical quantity can be reduced to the determination of these three fundamental quantities, it may be regarded as completed, at least theoretically. When any quantity is measured in terms of the fundamental units of time, length, and mass only, it is said to be expressed in *absolute* measure. It will be one of our objects in these papers to show that all electrical quantities may be expressed in terms of the second, the centimetre and the gramme, or in terms of any other set of fundamental units. The system, which is based on the centimetre, gramme, and second is called the C.G.S. system of units.

Geometry is the science which deals with pure space. If we consider space and time together we enter on the subject of kinematics. When we introduce the motion of mass as well as space and time we have dynamics. Thus dynamics must be regarded as the basis of all physical science.

Except when otherwise stated, we shall confine ourselves throughout these papers to the units of the C.G.S. system and the practical units derived from them.

Def. Velocity is the degree of quickness with which anything is moving. The unit of velocity is the velocity of a point which traverses the unit of length in the unit of time. Hence our unit of velocity will be a centimetre per second.

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The measure of the velocity of any point moving uniformly will then be equal to the number of centimetres passed over by it in the course of a second.

DEF. Acceleration is the rate of increase of velocity. The unit of acceleration is that of a point whose velocity is increased by unity in the unit of time, or, by one centimetre per second in each second, so that the measure of a uniform acceleration is equal to the number of units of velocity added in the unit of time.

DEF. The momentum of a body is the product of its mass and its velocity. The C.G.S. unit of momentum is that of a gramme moving at the rate of a centimetre per second.

When we pass from the consideration of pure kinematics to that of the motion of material bodies, we must have recourse to observation and experiment. Newton summed up the results of such observations and experiments in three brief statements, called the *Laws of Motion*. These, like other physical laws, must be regarded simply as concise statements of the results of experience.

LAW I. *A body under the action of no external force will remain at rest or continue to move uniformly in a straight line.*

Hence we deduce the definition of force, viz.:—

Force is that which changes or tends to change a body's state of rest or motion.

The first law of motion thus furnishes a *qualitative* definition of force. The second law gives its *quantitative* measure.

LAW II.—*Rate of change of momentum is proportional to the impressed force, and takes place in the direction in which that force acts.*

A force is, therefore, proportional to the change of momentum it produces in the unit of time. If we take as unit force that force which produces the unit of momentum in the unit of time, the measure of any force will be equal to the number of units of momentum which it generates in the unit of time. The C.G.S. unit of force is that force which acting on a gramme for a second produces in it a velocity of a centimetre per second, and is called a *dyne*.

DEF. A force is said to do work when it moves its point of application in its own direction, or an agent is said to do work when it overcomes resistance.

The work done is proportional to the product of the force and the distance through which it moves its point of application in its own direction, or proportional to the product of the resistance overcome and the distance through which it is overcome. If the force act vertically, and the body be moved along an incline, in estimating the work done we must measure only the vertical height through which the body is raised or falls, and generally, in whatever direction the force acts, the displacement must be measured in that direction. If the body moves in the *sense* in which the force acts, work is done *by the force*, but if it be made to move in the opposite *sense*, work is done *against the force*. The unit of work is the work done by the unit of force in moving its point of application over the unit of length. The C.-G.-S. unit of work is the work done by a dyne in moving its point of application over a centimetre, and is called an *erg*.

The weight of some particular body, such as the unit of mass, is sometimes taken as the unit of force, and is called a *gravitation* unit. The objection to such a unit is that it varies in different localities, being about one-half per cent. less near the equator than near the poles. If the weight of a pound be taken as the unit of force, the unit of work will be the work done in lifting a pound one foot high against gravity, and this is called a foot-pound. It is equal to about 13,560,000 ergs.

DEF. The power of an agent is the rate at which it can work. The unit of power is that of an agent which can do the unit of work in the unit of time. The C.G.S. unit of power is that of an agent which can do one erg. in one second, and one erg per second is the C.G.S. unit rate of doing work.

DEF. An agent which can perform 33,000 foot-pounds of work in one minute, or 550 foot-pounds in one second, is said to be of *one horse-power*. The horse-power is equal to about 7,458,000,000 C.G.S. units of power. Thus, an agent of one horse-power can do 7,458,000,000 ergs per second, and we can always determine the H.-P. at which any agent is working by dividing the number of ergs done in a second by 7,458,000,000, or, with sufficient accuracy for most purposes, by dividing by 7,460,000,000. The rate of doing work equivalent to 10,000,000 ergs per second is called a *watt*.

Newton's third law of motion is as follows:—

LAW III. *Action and reaction are equal and opposite.*

In the first interpretation Newton gives of this law he points out that whenever one body presses or pulls, attracts or repels, another, it is pressed or pulled, attracted or repelled by the second body with a force exactly equal to that which itself exerts, so that forces always come into existence in pairs, each pair consisting of two equal and opposite forces, or an action and an equal and contrary reaction. Action and reaction together constitute a *stress*, and the forces themselves may be regarded simply as aspects of the stress. It is, however, often convenient to abstract one of the forces, together with the part of the system on which it acts, and to omit the consideration of the other force or opposite aspect of the stress. Thus, we may consider the effect of the sun's attraction on the earth's motion without taking into account the equal and opposite attraction exerted by the earth upon the sun, and the consequent disturbance of that body.

In Newton's second interpretation of the third law of motion, he states the principle of the conservation of energy, so far as it could be stated before the fate of the work done against friction and other similar forces was known.

DEF.—The energy of a system is its capacity for doing work, and is measured by the number of units of work it is capable of performing in passing from its existing state into some standard condition.

A mechanical system may possess energy in virtue of (1) its configuration, or the relative positions of its parts, or (2) of the relative motions of its parts.

The energy possessed by a system in virtue of the relative positions of its parts is called its *potential energy*. The energy which it possesses in virtue of the relative motions of its parts is called its *kinetic energy*.

The work done by a falling weight or a bent spring is due to the potential energy of the earth and weight or of the elastic spring, while the work done by a cannon shot on its target is due to the kinetic energy of the system consisting of the earth and target and the cannon shot moving relatively to them.

The principle of the conservation of energy was stated by Maxwell as follows:—

The total energy of a system is a quantity which can neither be increased nor diminished by any actions between the parts of the system, though it may be transformed into any of the forms of which energy is susceptible.

When work is done against forces which, like gravity, are independent of the motion of the moving body an equivalent amount of *potential energy* is produced.

When work is done against forces which, like friction, are reversed in direction as soon as the direction of motion of the moving body is reversed, an amount of *heat* is generally produced which Joule proved to be always equivalent to the work so done.

When work is done in producing motion in a body an equivalent amount of *kinetic energy* is produced.

Thus, in the most general case, if an agent do work upon a mechanical system, some of the work done has its equivalent in potential energy, some in heat, and some in kinetic energy developed in the system.

Heat is in reality a form of kinetic energy, but it is due to the motions of molecules, and not of tangible bodies.

DEF. The unit of heat is the amount of heat required to raise the unit mass of water from 0°C to 1°C.

Joule showed that the amount of work which, if entirely converted into heat, would raise 1lb. of water from 0°C to 1°C was 1,390 foot-pounds.

Hence the amount of work which, if entirely converted into heat, would raise one gramme of water from 0°C to 1°C is about 42,000,000 ergs. This is called the mechanical equivalent of heat.

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NEWSPAPER SCIENCE.

Although we have never been enthusiastic advocates of science for the multitude, we would certainly make an exception in favour of newspapers editors. If, consistent with the discharge of their important duties as promoters of experimental politics, they could spare time to take a few lessons in elementary physics, their clients would be greatly the gainers. We might add that they—the editors—would be spared much ridicule by taking the course we suggest; but ridicule is not a weapon that reaches the anonymous scribe. Life would be unendurable to him—we include ourselves in this observation—if everything he wrote, or permitted others to write, were brought home to him to endorse. Still, in the interests of the public, for whom the journalist professes to live, he might, one would think, include a smattering of science in his professional training. For the writing of certain daily leaders the storehouse of history, both ancient and modern, sacred and profane, seems to have been ransacked from bottom to top, whilst for certain others the learned author has climbed that dizzy height from which, with far extended view, mankind is surveyed from China to Peru—so the admiring reader thinks, and we are not going to undeceive him. But the labour and the study, whatever they may be, are certainly greater than that required, say, for the mastery of Ohm's law, or a right understanding about the conservation of energy.

Ignorance on these two points alone has led the newspapers one and all into a number of extraordinary errors just lately, some of which may not only mislead but seriously injure the public. From the extreme of thoughtless speculation on the capabilities of electricity for any and every purpose under heaven—speculation which led to operations bearing the same name in the Money Market—we are now witnessing an equally thoughtless scare in respect to the danger attending the use of it. This, too, furthers speculation of the material sort, and will, it may be feared, result in the enrichment of a few people who do not believe in alarming letters inserted by newspaper editors, at the expense of a multitude who do.

The leading journal is, as usual, the foremost offender in this respect. It was the first to make known the fabulous merits of a certain kind of battery; it is now the first to get up a scare against the use of it. The other newspapers, not to be behindhand—first, in telling people how they may put money into their pockets, then in telling them how foolish they have been to take the advice—of course follow suit; and then there comes a panic. It is all done in perfect good faith no doubt, the public instructors acting according to their light for the time being in every case. But what we say is, they might spare themselves the necessity of eating their own words, and their readers the expensive luxury of swallowing them, if only they, the learned editors, would take the trouble to understand a little what they are writing about.

The forthcoming pantomimes are the immediate text for alarms. "Some dreadful accident may occur to arouse public indignation," and so forth. Hardly a Christmas passes without some accident, more or less dreadful, generally due, it must be confessed, to the careless use of exposed gas lights. But because some heartless managers contemplate the introduction of electric light in order to add either to the beauties or the horror of the spectacle, we are forthwith warned against its appalling danger. We quite agree that the life of "a super at 20s. a week" ought not to be "put in jeopardy" by any theatrical manager "autocratic" or the reverse. But we do not precisely apprehend where the danger is. Certainly not from a battery sufficient only to charge one small lamp, for that appears to be the thing to be personally feared. The electrical resistance of the human body is very considerable, and in this respect a ballet girl, we imagine, differs in no way from less etherial mortals. We would not so much as singe the hem of her garment to please a thousand theatrical managers; but in sober truth we could not do it if we tried, not at least with the electricity at command in the proposal we are referring to.

Passing from the meretricious brilliancies of the stage, we have been witnessing a grand display of nature's splendours in the heavenly arena far and wide; and this, of course, has brought forth the inevitable crop of startling discoveries. Milwaukee is a place with an outlandish name, and of all the outlandish things which come from America, Milwaukee, of course, is credited with a disproportionate share. It is a modern El Dorado and Golconda of scientific jewels. Such is the virtue pertaining in this wonderful town that during the recent magnetic disturbances, that is to say while the aurora borealis was shining in the firmament above, an

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electric light was illuminating Milwaukee below, maintained solely by the magnetic disturbance. An eight horse-power engine is usually required to keep that light going. On the night in question Milwaukee appropriated the aurora, and dispensed with the engine. Hence it follows that if the United States of America, which telegraphs this information to Europe for our edification, will only keep us supplied with the requisite amount of "magnetic disturbance," of the 8 h.-p. sample, such as prevails at Milwaukee, our electric lighting can obviously be maintained in a very literal sense "regardless of expense."

These are the natural deductions of people who trust to the newspapers for their guidance in matters relating to electrical science. Of an opposite character were some warnings which originated in the same quarter not long ago in reference to fires. It would be exceedingly dangerous, said the newspaper paragraph, for any fireman to chop an electric lighting wire with his axe, as the current might travel up the handle and do him an injury. The same paragraph even warned him against playing upon any wire charged with an electric lighting current lest it found a passage to earth by way of the jet of water, the hose pipe, and the fireman's body!

STUDENTS' COLUMNS.

These answers are intended to guide, to give information and references, to put the student in the way of getting information, and *not* to give the exact answers that should be written in an examination.

Question 5 (*continued*). Therefore the resistance increases.

$$\cdot 21 \times 28 = 5 \cdot 88 \text{ for an increase of } 28°\text{F.}$$

Thus the resistance of

105·88 feet at 32°F. = resistance of 100ft. at 60°F.

We have seen

250ft. of this wire has R = 1 ohm at 32°F.

and as 105·88ft are, under the above conditions, equivalent to 100ft. under the given conditions,

$$\therefore \frac{100}{105 \cdot 88} \times 250 = \text{No. feet with R} = 1 \text{ ohm at } 60°\text{F.}$$

$$= 236 \text{ nearly.}$$

The percentage increase due to a rise of $t = 15°$F.

$$= \cdot 21 \times 15 = 3 \cdot 15.$$

4. A joint has to be made between the ends of two thick electric light wires. Explain and give sketches of the method of jointing you would employ. In carrying wires, between which there is an electromotive force of 300 volts, through the rooms of a building what method of insulation would you make use of? Show exactly how you would lead the wires to a number of incandescent lamps suspended from a bronze chandelier, and give the reasons for adapting your method.

Ans. For first portion of Answer 5, method of jointing proposed by the Society of Telegraph Engineers in the Rules and Regulations issued by the Society. The Rules were given in Vol. IX., p. 179.

Architects, as a rule, make no provision for pipes or channels for conveying wires, &c., in their plans; but in designing a new building to be lighted by electricity such provision should be insisted on. The arrangements to be followed where no such provision has been made must vary with the circumstances of the case. It should be an axiom with electric light engineers to have an ample margin of safety in their conductors, and to obtain the best protection from damp. The wires should be covered with, besides other insulating material, at least one taping of india rubber. If a small wooden tube could be used in which the wires could be laid, and surrounded with, say, paraffin, the wires being in two divisions of the tube, or in two different tubes, there would be little danger from any short circuit through damp. Or the wires might be insulated with gutta percha, or ozokeritised rubber, but in any case we should prefer to use, in conjunction with such wire, the channels, and further surround the covered wire as described, or with some other cheap resinous insulating material.

The main wires would be carried, as above described, along the joists directly above the chandelier. The chandelier would be, or ought to be, designed with hollow branches, radiating from a larger hollow central stem. Two insulated wires would be taken from the lamp screws, that is, on opposite sides of the branch, through a small hole in the stem, and along the stem to the leading wires, to one of which one wire would be joined, the other wire being joined to the other main wire. The lamp socket would contain contact arrangements, so that the turning of a plug would make or break the circuit of that particular lamp.

[We imagine from the fact that reasons are required, this question was framed to get somewhat into the "individuality" of the examinee. No two answers could be exactly alike, unless the student had been "crammed," because the number of ways of doing these things is practically infinite.]

6. What is the electromotive force in volts of a Daniell and of a Grove cell? What is the electromotive force of the dynamo you are best acquainted with, running at some definite speed, and with some special resistance in circuit? How, exactly, is this electromotive force altered by increasing the speed? In the case of a magneto-electric machine, how does the electromotive force vary with the speed? Explain fully the cause of the difference, if any, in the effect of speed on electromotive force in the dynamo and in the magneto machine.

Ans. Daniell ..... 1·079 volts (Clark and Sabine).
Grove ..... 1·956 „ („ „).
B. Bürgin at 1,550 revs. has E.M.F. of 200 volts } *Electrician*
B_1 „ „ „ „ 160 „ } supple-
C „ „ „ „ 300 „ } ment.
Gramme 1,000 revs. has E.M.F. of 107 volts with ext. resist. = 2·7 ohms ..... } (Adams, Cantor Lectures).
Siemens 1,000 revs. has E.M.F. 42 volts through about 2·2 ohms ..... } „ „

Dr. Hopkinson has shown the following with regard to the E.M.F. of a Siemens machine:—

(1) The E.M.F. is, for a given current, proportional to the speed of revolution of the armature.
(2) The E.M.F. does not increase indefinitely with increasing current, but
(3) Only increases in the direct ratio as the current increases up to about two-thirds of its maximum value.

Mr. R. E. Crompton states that the E.M.F. of the Bürgin machine is directly proportional to speed between 1,000 and 1,700 revolutions.

[We must refer students to Dr. Hopkinson's papers, read before the Institution of Mechanical Engineers in 1879-1880, where they will find references for further information than is given in the papers. The second paper is given in *The Electrician*, Vol. IV., p. 295. It must be remembered that magneto and dynamo machines have the one permanent the other electro magnets. The field of the one is practically constant, and hence E.M.F. is to be taken generally as proportional to the number of revolutions, but in the other case this holds good only within limits. Up to a certain number of revolutions the electro-magnets are constantly increasing in effect, then comes a point after which the field is pretty constant, and the E.M.F. is proportional to the revolutions.]

7. A certain magneto machine, when running at 500 revolutions a minute, produces an electromotive force of 8 volts. What current in amperes will it send through an external resistance of 50 ohms when running at 750 revolutions a minute if its own resistance is $1\frac{1}{2}$ ohm?

Ans. As E.M.F. is proportional to the number of revolutions, the E.M.F. at 750 revolutions is found from

$$500 : 750 :: 8 : x,$$

whence

$$x = \frac{750 \times 8}{500} = 12.$$

From Ohm's law

$$C = \frac{E}{R + r},$$

when

C = current in amperes,
E = electromotive force in volts,
R = external resistance in ohms,
r = internal resistance in ohms.

Putting the values for E, R, and r, we have

$$C = \frac{12}{50 + 1 \cdot 5} = \frac{12}{51 \cdot 5} = \cdot 0233 \text{ nearly.}$$

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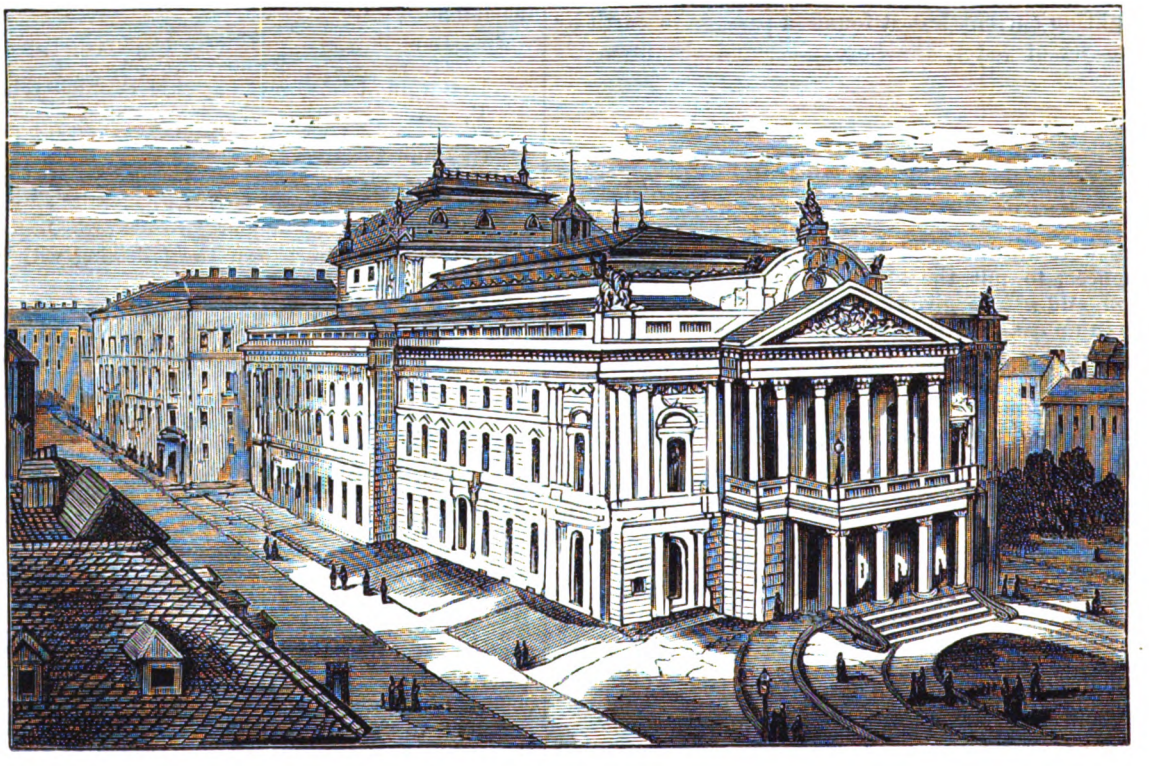
ELECTRIC LIGHTING AT BRÜNN.

BY FRANCIS JEHL.

Brünn, in Moravia, which is the chief manufacturing centre of the Austrian empire, has now beyond doubt the finest installation of electric lighting on this side of the Atlantic. The new theatre, which is owned and governed by the municipal council of that city, is entirely lighted by the Edison system of electric lighting. The building, which occupies a whole square, contains about 1,600 lamps, and has no connection with gas whatever. This theatre has all the modern improvements that can be suggested. Owing to the calamities that have befallen some theatres of late years, the city has taken great precaution to secure a place of amusement which is absolutely safe against fire. The auditorium is separated from the stage by a wall one metre thick, and an iron curtain, worked by hydraulic engines, so that at a moment's notice one part of the building can be separated from the other. All the lights on the stage and auditorium are governed by regulators, and can be varied to any desired intensity. There are six rows of cross lights, each row being divided into three circuits, having 40 lamps each, making in all 720. Each one of these circuits can be regulated, or all together. Then the foot lights, which are divided into two sections, have three circuits each, and contain an aggregate sum of 180 lamps. There are 60 lamps to be used as portable ones, coming from underneath the stage by means of flexible cables. Thirty more lamps, to be worked by flexible cables, come from the first stage gallery, and 60 more for the uprights on each side of the stage, making 1,050 lamps on the stage alone. The main electrolier has 60 lamps, and 110 more are scattered in different parts of the auditorium, amounting to 1,220 lamps, which are operated by regulators similar to those used for gas. The regulators consist simply of resistance coils, made of German silver wire, and are inserted into each circuit which is required to be operated. Each regulator is divided into many parts, so that nicety of variation can be obtained. The resistance and size wire used for each regulator depends upon the number of lamps in its circuit. The regulators used here are so constructed that lamps at 16 candle-power can be gradually turned down until the carbon becomes black. Each row of the cross-lights, as before stated, has three circuits, each circuit containing forty lamps, which are of a different colour, namely, red, white, and green. The object of this is to produce the different colours of the day; for representing the night the green lamps are regulated, and as morning comes on the red lamps come into play, and then the white. We have also an arrangement to imitate lightning. This is done by having an apparatus which will break a circuit, having a strong current, very quickly. The spark thus produced resembles lightning. All main lines, branch circuits, and electroliers are provided with safety cut-outs, which will interrupt any circuit the moment an abnormal amount of current begins to flow. The general plan for regulation may be understood by inspecting Diagram 1. Here R represents the main regulator, which will regulate all lights at the same time. R′ is the regulator that will regulate all the cross-lights at the same time, while R‴ are regulators that govern the circuits in which they are connected. There is a two-pointed switch connected to the first ten top regulators, the object being to throw the red or white lamps in circuit when needed, as the three different colours are never needed at the same time. The diagram shows only one line or pole, the return circuit being common for all. The object of a regulator or resistance-box is to increase or diminish the strength of the current passing through it. It is economical to construct a regulator of a size wire that will just carry the current intended for it, without becoming heated to any extent. The stronger the current the heavier the wire must be, and, consequently, the more the cost. In regulating only a portion of the lights in a system it becomes evident that the electromotive force at the terminals of the machine must remain constant, and that in order to diminish the current in any portion of the system it must be done by inserting a resistance in that circuit. Now, as in the case of lamps in a theatre, the resistance of the regulator depends upon the number of lamps in its circuit; the less the number of lamps the higher the resistance, and the greater the number of lamps the lower the resistance. It is well to use small size wire, joined in multiple-arc, as it gives more surface and therefore does not heat so much as the same weight of metal in one large wire would. To construct a regulator that will regulate with nicety, the following facts must be taken into consideration:—

Let R equal the resistance of the number of lamps used at



Theatre at Brünn.

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16 candles, while E is the electromotive force required to keep them at that candle-power. By Ohm's law we find that the current is $\frac{E}{R}$, which let us suppose to be C. Having, therefore, found the current that keeps them at 16 candles, it is desired to ascertain the intensity of the current required when they give no visible light. This must be determined by experiment, carefully noting the electromotive force and resistance at that point. Let us suppose that the resistance in this case is R′, and the electromotive force E′, the current therefore being $\frac{E'}{R'}$, which let us suppose to be C′.

The difference in the strength of the current in both cases is found by subtracting C′ from C, which let us suppose to be *a*. Our object, then, is to have a resistance that will produce that difference with a constant electromotive force of E. This can be determined by the following equation, where E equals the electromotive force required to keep the lamps at 16 candles, and C′ the current required to keep them at the

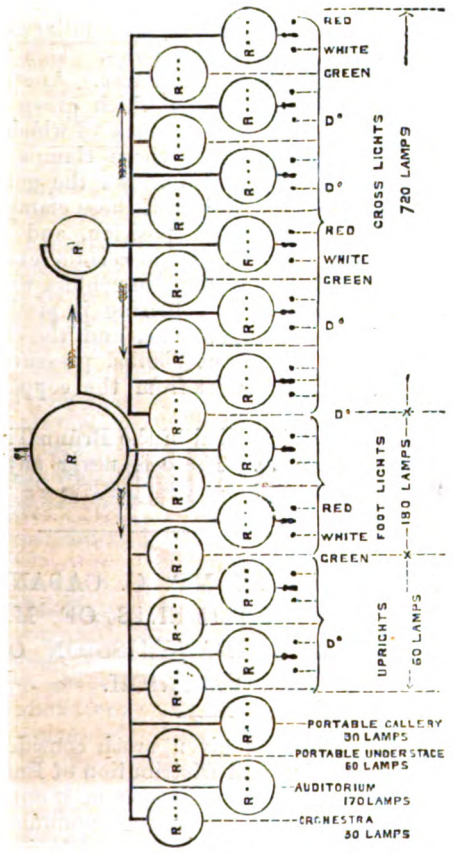

FIG. 1.

invisible points, x being the resistance we wish to determine:—

$$C' = \frac{E}{x},$$
$$C'x = E,$$
$$x = \frac{E}{C'}.$$

Now, as the resistances of our lamps are included in x, the artificial resistance can be expressed by

$$x - R' = \text{artificial res.}$$

Having thus found the resistance required we must find what size wire will carry the current most conveniently. This must be ascertained by experiment. The following formula will answer all practicable purposes:—40 here is a constant already determined by experiment, and I is the intensity of the current—

$$40\sqrt{I} = \text{wire in } \cdot 01 \text{ of mm.}$$

This formula is only good for German silver, which is the best alloy for the construction of resistance boxes, as it does not change its resistance so much with a change in its temperature as other metals do.

Having the diameter of the wire, the length required is easily found by measuring how many meters or fraction of a meter there is to a unit of resistance. Now, when this resistance is inserted into the line, the best effect is produced by introducing it slowly, that is, small portions of it at a

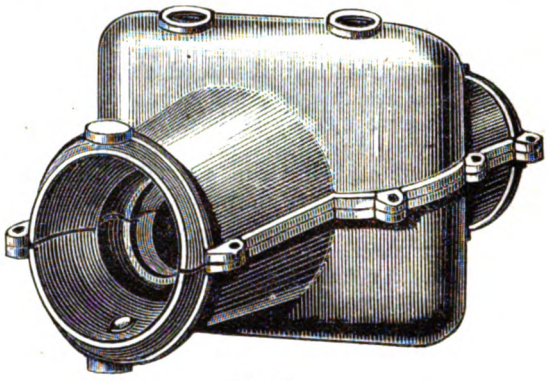

FIG. 2.

time, so as to prevent jumps. This is done by having many contact points on the switch board intended to operate the resistance, the greater the number of points the better the effect produced.

Four dynamo machines known as the K kind supply the current. Each machine is capable of supplying with ease the current required for 250 lamps of 16 candle-power each. The resistance of these machines is ·03 ohms, thus making a

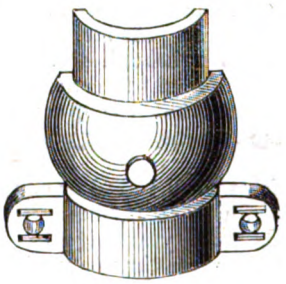

FIG. 3.

ratio of 1 to 20 when the resistance of the lines is taken into consideration. The K machines consist of three magnets, such as are used on ordinary 60-light machines, coupled together. The armature is, therefore, three times as long as the bobbin of the 60-light ones, and consequently has three times the magnetic surface, and at the same time has one-third the dead wire that three 60-light machines have. The weight of wire used on a K is about the same as the weight

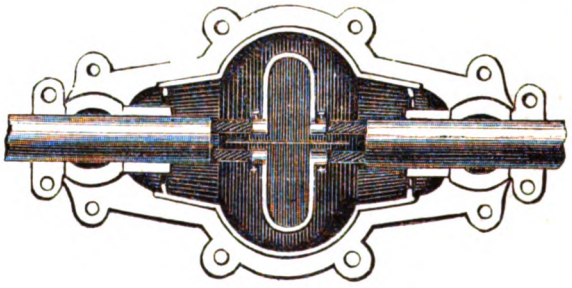

FIG. 4.

used on three small machines. This shows the economy that large machines have over small ones. For example, in the above case the resistance of three 60-light machines coupled together is about ·046 ohm, a certain portion of this being ineffective and yielding no current, but unavoidably so, as it forms a portion of the circuit in which the effective wire lies. This ineffective or dead wire lies at the back and front of an armature, and it is evident that by using the same

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weight of wire used in three small machines and transforming it into one large machine the loss is much less, as we utilise two-thirds of the wire that would have been dead in the small machines. Then we gain in another point, that is, if we have the same number of coils in the large machine as in the small ones, the speed being the same, we would create an electromotive force of three times that which one small one would. This, however, is not desired; the object is to produce an electromotive force equal to that of the small one. This can be done in two ways, first, by running the machine slower, and, secondly, by making a less number of coils in our machine. (It must be understood that the intensity of the field magnets are supposed to be constant in both cases.) Now, in our case we employ both ways; we run our large machine slower, because it is heavier, and, consequently, would not permit of being run as fast as the small ones, although it would be very desirable. Then we make the large machine of a less number of turns, electromotive force turns, if I may use the term, and fill up the space with current or quantity turns. This makes the machine of a low internal resistance, lower than the coupled resistance of three small ones, and therefore permits of having a heavier load or more lamps than the small ones. This is seen in the above case, where one machine has 250 lamps, and the same amount of wire used in a different manner can only carry 180 lamps. If it were not for mechanical difficulties, that is, if we could lessen the amount of friction generated at the bearings and run the machine faster, we would gain more per weight of metal. This holds true for all machines, large or small. The requirements of a good dynamo machine are, first, that it should transform nearly all the mechanical energy given to it into electrical energy; and secondly, it should be so constructed and used that nearly all the electrical energy can be utilised, and therefore become productive. This can be done by making the resistance of the armature as low as possible, and so constructed that nearly all the wire cuts through the magnetic field. Then, again, the field magets ought to consume as little current as possible. It is found that the greater the weight of iron used with the same current, the stronger the magnetism produced.

All the above facts can be used or employed within certain limits, outside of which it becomes impracticable. It was Mr. Edison's study some years ago to discover where these limits lay, and at the same time to utilise all the laws governing electricity and magnetism in the construction of his machine.

The line that conveys the current from the machine house to the theatre is about 350 meters long, and is laid underground about one meter deep. The electric tubes used are of the latest pattern manufactured by the Edison Tube Company, of New York. These tubes have a much stronger armour than those of previous date, the iron tube encasing the copper mains being nearly double as thick as the first ones. The tubes employed in Brünn are known as the No. 1·5 size, the copper mains containing about 1,296,419 circular mils, which is equal to about 72 No. 10 wire B.W.G. These tubes come in lengths of about 20·5ft., the copper projecting about two inches, which allows of being connected together by means of copper clamps formed into a V shape so as to allow for expansion and contraction. The two wires are held firmly apart inside the tube by cardboard washers, which prevents them from touching each other, or the iron pipe that protects them. This is then filled with some insulating composition, manufactured by the tube works, especially for their tubes. The tubes are all then tested, by means of a Thomson high resistance reflecting galvanometer, with 200 Daniell elements. No tube is allowed to pass unless it gives a resistance of over 300 megohms. The following is briefly the manner in which tubes are laid. Each length, when required, is taken, and the copper terminals thoroughly cleaned, so that they admit of being well soldered to the expansion clamps. It is then laid into the ground, care being taken to prevent any dirt coming in contact with the ends. Another such a length is then placed at about two inches distant, a junction box being placed at that point, and the V shaped clamps connected to the ends of the tubes. After these have been thoroughly fastened together, by means of screws, they are soldered so as to insure perfect contact everywhere. In order to do this perfectly a jet of hydrogen gas is used, as the heat so generated is greater than that which can be obtained in any other practicable way. It must be remembered that it takes a large amount of heat to solder such joints, as the copper is large, and being a good conductor, the heat dissipates very fast. After this is done the box is cleaned out, and a piece of cardboard well saturated with paraffin is inserted between the two poles. The cover is then bolted on, and filled with insulating compound, the two holes on the top being then plugged up by means of screw plugs.

The electric tubes permit of being bent to nearly an angle of 90 deg., and tests have shown that it does not impair their insulating qualities in the least. Fig. 2 shows the latest form of junction boxes, which have many advantages over the old ones. One of the improvements consists in being a little higher than the old ones, and when full of compound, which when cold shrinks, still protects the cardboard that separates the poles. It has happened in the old ones that, after the shrinkage of the compound, the vacuum produced would suck in moisture, and by capillary action would communicate some between the poles. This objection is entirely surmounted in these new boxes. Another improvement consists in the iron clamps which grasp the tubes at both ends of the junction box, an idea of which can be got from Fig. 3. The application of these clamps is best seen by inspecting Fig. 4, which also shows the general way of connecting up tubes. The object of these clamps is to hold firmly the tubes in a horizontal position, and at the same time allow them to deviate to a certain extent without causing the copper clamps to come in contact with the box.

The hydrogen gas used in soldering is produced by the action of sulphuric acid upon zinc, and the charges are so proportioned as to give about 250lbs. pressure per square inch. The gas is used direct from the copper cylinder in which it is generated.

Of the 1,600 lamps installed in the Brünn Theatre, about 1,000 will burn at a time. There is never any occasion to use them all at once.

THEORY APPLIED BY MR. G. CABANELLAS TO THE RECENT EXPERIMENTS OF M. MARCEL DEPREZ ON THE TRANSMISSION OF POWER FROM MIESBACH TO MUNICH.

M. Cabanellas, who has given much consideration to the questions of Production and Distribution of Energy by Electricity, and who is the author of a system of automatic working of such a problem, has just communicated to the "Academie des Sciences" of Paris the following theory:—"*In the transmission of mechanical energy by means of two identical dynamo-electric machines, the ratio of the speeds does not express the value of the return; the return is equal to the product of the ratio of the speeds into the ratio of the fields.*"

Those who have had experience with dynamo-electric machines have remarked that for a given number of revolutions, per unit of time, of the generating machine, the maximum work is not obtained from the receiving machine when this is allowed to go at half the speed of the generating machine; but for a large number of types of machines the receiving machine should go at two-thirds the speed of the generator to obtain the maximum mechanical work. This fact, however, is in contradiction to a theory which is found in several scientific works, a theory which admits implicitly or explicitly the equality of the fields of the generator and receiver. But it must be granted by every one that from Lenz's law there follows the necessary reaction between the field and the moving current in each machine. The theory of M. Cabanellas takes exact account of all experimental results; his example shows how great this reaction may become with high speeds. M. Cabanellas's communication

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is, moreover, of great interest on account of the general method of reforming the electric elements which he applies to the particular case of the experiments of M. Marcel Deprez as to speeds, differences of potential and current observed at Munich by the engineer who carried out the following experiments in accordance with the instructions of M. Marcel Deprez.* Now that very exact instruments for measuring current and difference of potential are obtainable, the value observed by the easy method of M. Cabanellas for the total work given electrically to the generator has every reason for being much more exact than the value of the work obtained by interposing a transmission dynamometer between the mechanical source of power and the generating dynamo, since at a speed of 2,200 revolutions per minute the error introduced in the traction pull and thence in the work of one revolution is multiplied thirty-six times in the determination of work per second. In this method M. Cabanellas has profited greatly by his former experiment on the increase of internal resistance of machines when running.

"In a series of studies on electrical machines communicated to the 'Academie des Sciences,' I have analysed the theoretical reasons which differentiate the reflex magnetic and electric elements of a machine according as this machine is worked mechanically to create electric currents or is worked electrically to produce mechanical work. But No. 15 *du Tome XCV. des Comptes Rendus* (October 9th, 1882) has on page 633 a note from M. Marcel Deprez, the conclusions of which prove to me that in the interest of science and its applications it is indispensable to call attention to the results of the experiments of which I have spoken in a manner sufficiently concise for the figures to be followed. M. Marcel Deprez gives the results of an interesting experiment on the transmission of power to a great distance, which he has made from Miesbach to Munich (57 kilometres of overhead telegraph line). According to the note the receiving Gramme machine developed half a horse-power measured on a brake at 1,500 revolutions per minute, an identical Gramme generator at Miesbach running at 2,200 revolutions. M. Marcel Deprez concludes that 'subtracting the passive resistances of every kind the ratio of the work reproduced at Munich to the work expended at Miesbach was as $\frac{1500}{2200}$ = more than 60 per cent.' It was a departure from the above-quoted theory that caused M. Marcel Deprez, in the preceding assertion, to make an error which is very far from negligible, since I will show that *from the results of this experiment, the return, instead of being about* 60 *per cent. was about* 20 *per cent.*, that is to say, about one-third as much as the author of this experiment imagined. The above-mentioned notes, besides the speeds of the machines and the work reproduced, give only the resistances (*in repose*) of each of the two machines (470 ohms) and the total resistance (line wire and return) of the telegraphic circuit (950 ohms). There would not be in this the elements necessary for a numerical estimation, but I find the following series of figures in a recent publication which relates to the experiment at Munich (*Bulletin de la Cie Internationale des Telephones*):—Power transmitted, $\frac{1}{2}$ h.-p.; resistance of each machine, 460 ohms; resistance of line, 1,000 ohms; speed of generator, 2,100 revolutions; speed of receiver, 1,400 revolutions; difference of potential between the terminals of the generator 2,400 volts, and between the terminals of the receiver 1,600 volts; current, 0·5 ampere. It will be seen that the two sources of information present in what they have in common an agreement sufficient to permit both to be taken as the base of an approximate calculation. It is reasonable to take without selection the figures of the most complete source which can be applied, although they are a little different from those of the experiment noted by M. Deprez. Let i = current, E the electromotive force of the generator, e that of the receiver, r the resistance of the generator *when working*, ρ that of the receiver, R that of the line, E the difference of potential at the terminals of the generator, $E_{,}$ the difference of potential at the terminals of the receiver, t the mechanical work reproduced per second (kilogramme-metre), t' the useless work of the receiver through rubbing of the brushes and resistance of the air, g the acceleration of gravity. Neglecting at first the work done uselessly we have:—

$$E_{,} i = g t + i^2 \rho \therefore \rho = \frac{E_{,} i - g t}{i^2} = \frac{1600 \times 0{\cdot}5 - 10 \times 37{\cdot}5}{0{\cdot}5^2} = 17000 \text{ ohms},$$

and $e = E_{,} - i \rho = 1600 - 0{\cdot}5 \times 1700 = \frac{g t}{i} = 750$ volts.

But the resistance of the machine in repose is 460 ohms, and therefore the increase for 1400 revolutions is $1700 - 460 = 1240$ ohms. The increase for 2100 turns will be $\frac{1240 \times 2100}{1400}$, and hence for the generator $r = 460 + 1860 = 2320$ ohms, and $E = E + r i = 2400 + 2320 \times 0{\cdot}5 = 3560$ volts, and therefore the return is $\frac{e i}{E i}$ or $\frac{e}{E} = \frac{750}{3560} = 21{\cdot}06$ per cent., admitting that the current is not less at the receiver than at the generator, which would again lower the return. As verification, $i = \frac{E - e}{r + R + \rho} = \frac{3560 - 750}{2320 + 1000 + 1700} = 0{\cdot}55$ ampere, which would represent a loss of $\frac{5}{100}$ ampere $= \frac{1}{11}$ of the current in a total length of wire of more than 100 kilometres. The positive and negative tensions vary gradually from a difference of 1200 to 800 volts with the potential of the earth. If it is wished to take account of the work t' reproduced uselessly in the receiver, the formula becomes $E' i = g t + g t' + i^2 \rho_{t'}$, $\rho_{t'} = \frac{E_{,} i - g (t + t')}{i^2}$ $e_{t'} = E_{,} - i \rho_{t'} - \frac{g t'}{i}$, and since $\rho_{t'} = \rho_0 - \frac{g t'}{i^2} \therefore e_{t'} = E_{,} - i \rho_0 = e_0$, which should be *à priori*. The useless work t' is easy to measure dynamically, and even electrically, by a method which I have communicated, and which has been inserted in the *Comptes Rendus*. In the absence of direct measurements, we may estimate this useless consumption at $\frac{1}{10}$ of the mechanical power reproduced by the receiver, *i.e.*, at 3·75 kilogramme-metres per second. The above formula gives us for $t = 37{\cdot}5$, and $t' = 3{\cdot}75$, $\rho = 1550$ ohms, $e = 750$ volts without any change, increase for 1400 turns = 1080,

$$r = 470 + \frac{1080 \times 2100}{1400} = 2090 \text{ ohms},$$

$E = 2400 + 2090 \times 0{\cdot}5 = 3445$ volts, $\frac{e}{E} = \frac{750}{3445} = 21{\cdot}77$ per cent. Using the figures of M. Deprez's note for inert resistances it would be $i = \frac{3445 - 750}{1550 + 950 + 2090} = 0{\cdot}58$ ampere. All our conclusions stand. If in the numerator of i we take account of the difference of potential lost through derivation, on the line we find 0·51 ampere. We have judged it interesting to pass through all the details of the reconstruction of the electric elements, for we might have at once applied the formula.

$$\text{Return} = \frac{g t}{E i + \frac{N}{n}\left[E_{,} i - g\left(t + t_{,}\right)\right] - a i^2 \frac{N - n}{n}}$$

which applies if the line is perfectly insulated. $N_{,}$ $n_{,}$ are the speeds of the generator and receiver, a is the resistance of the machine in repose at the strength of current i. But the formula

$$\text{Return} = \frac{g t}{E\,I + \frac{N}{M}\left[E_{,\,I} I - g\left(t^{\,I} + t_{,\,I}\right)\right] - a\,I^2 \frac{N - M}{M}}$$

in which $E_{,I}$ is the difference of potential between the terminals of the machine worked at a speed M by a current I,

* M. Cabanellas has since acquired proof of the authenticity of these figures.

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the work got out by the brake being t_1 and the useless work t', a_1 being the resistance at rest under the strength of current I. The value of the current I at the generator being greater than i, the value of the current at the receiver approximately, in this case where the line is imperfectly insulated the formula

$$\text{Return} = \frac{g\,t}{E\,I + I^2\left[\frac{N}{n}\left(\frac{E_1}{i} - g\left(\frac{t+t'}{i^2}\right) - a\,\frac{N-n}{n}\right.\right.}$$

may be employed. With the preceding approximate figures a calculation would give I = 0·65, which would reduce the return to less than 15 per cent.

"The kind of calculation which I have just made shows how useful and practical is the consideration of the increase of internal resistance of machines when working, also with what ease it allows a great error to be rectified, and of finding the return which a measure of the power expended at Miesbach will give, a measurement which is particularly easy and exact if, as has been remarked, the generator is driven by a separate gas engine. In fact, when M. Deprez admits that the return is equal to the ratio of the speeds, he implicitly admits the equality of the magnetic fields of the generator and receiver, whereas through the reflex actions of which I have spoken (electric current in movement inducing magnetism) the generating field was more intense than the magnetic field which the same current would develop with the armature in repose or turning with an open circuit, and the field of the receiver was less intense than this field not influenced, so that according to the figures given the field of the receiver in this experiment would be three times less intense than the magnetic field of the generator.

"(Signed) "G. CABANELLAS."

ON THE ACTION OF THE MICROPHONE.*

BY PROFESSOR JAMES BLYTH, M.A.

In the microphone transmitter, as usually employed in circuit with a battery and a Bell telephone, we have essentially two pieces of carbon resting lightly against each other, through which the current passes. That the instrument may work effectively two things are requisite—first, that the carbons be always in contact, or, at least sufficiently near for the current to pass between them; and, secondly, that they be not pressed together so tightly as to prevent any motion of the one relatively to the other. This state of things is sufficiently well described by the term "loose contact," first used, I believe, by Professor Stokes.

To understand the action of the microphone, we have to find out what effects are taking place at the loose contact when the instrument is acted upon by sonorous waves. These are twofold—first, the effect produced by the sound waves (that is, the variation of density due to the condensations and rarefactions of the air) which pass directly through the air when they arrive at the loose contact; and, secondly, the effect produced by tremors set up in the entire instrument, wooden supports and carbons together, by the sound waves which strike against it, and are thereby stopped.

For distinction, we may call the first of these the *air effect*, and the second the *tremor effect*.

In my experiments I have endeavoured to arrange the instrument so as to isolate these effects, and, as far as possible, examine each of them separately.

To isolate the air-effect, it is obviously necessary, either to fix the carbons rigidly in their supports, so as to avoid any motion of the one relatively to the other, or to use a strong current, and place them just clear of contact with each other.

The following experiment illustrates how this may be done:—

A, B, and C (Fig. 1) are three blocks of brass firmly fixed to a heavy wooden sole-plate, S. To the top of A is soldered a piece of brass rod, *a*, about 2in. long and $\frac{5}{8}$in. bore. To the top of B is soldered a piece of similar tube, *b*, about 4in. long. Through C passes a fine screw worked by a milled head, *c*. A piece of carbon rod, *e*, is fixed firmly into *a*, and has a hole $\frac{1}{4}$in. wide drilled through its centre. A long piece of carbon, *f*, pointed at one end, passes tightly through the tube *b*, and can be moved backwards and forwards by the screw *c*. A piece of india rubber tube is passed over the left end of the tube *a*, and carries the mouth-piece M. By means of two wires which are soldered to the carbon rods, they are put in circuit with the battery (20 Grove cells) and the telephone T, which must either have a smaller resistance or be placed in a separate circuit from that containing the battery, so as to be acted upon inductively. When the carbon *f* is screwed tightly into the hole *e*, the circuit is completely closed, and no sound uttered into M is heard at T. But when *f* is drawn gradually back, until small electric arcs are seen to pass between *f* and *e*, every sound uttered into M is distinctly reproduced in the telephone T.

Here we have clearly only the air-effect acting, and that solely upon the small electric arcs passing between the carbons. I have found it, as yet, somewhat difficult to get the sounds to last for any length of time, in consequence of the arc distance soon getting too great for the current to pass and requiring re-adjustment. When the arc begins and ends a sharp click is heard in the telephone; but in the interval during which the arc lasts the sounds heard in the telephone are distinct.

As far as the tremor effect alone is concerned, it is obvious that the microphone action must depend, either (1) upon the variation of resistance due to variation of pressure, or (2) to variation in the extent of surface contact due to the elastic yielding of the carbons under pressure.

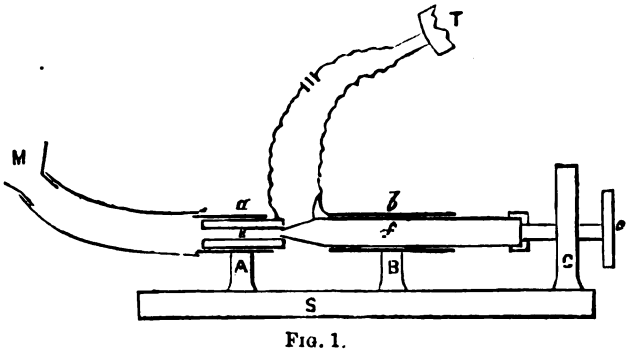

FIG. 1.

To test the first of these cases, I made, about two years ago, some experiments on the effect of pressure upon the specific resistance of carbon. For this purpose, I took a short length of carbon rod, and soldered wires to it at a short distance from each end. By means of these wires, the resistance of the carbon rod was balanced in the Wheatstone bridge. Pressure was then applied by means of a lever to the carbon in a longitudinal direction. No appreciable variation in the resistance was observed, even under considerable pressure, and it only became manifest when the pressure was sufficient to bend or crush the carbon.

I have recently repeated these experiments with the greatest care, and found the same results. I observe, also, that similar experiments, with the same result, have quite lately been made by Professor Sylvanus Thompson. Hence we can hardly, I think, believe that variation of specific resistance due to pressure can have the slightest effect in producing the microphone action. To test the second cause above mentioned, that is, the variation of resistance due to variation, in the extent of surface contact due to elastic yielding under pressure, I experimented as follows:—

In the apparatus already described I replaced the tubular carbon by a finely pointed piece, so as to have two fine carbon points exactly opposite each other. The resistance of the points was balanced in the bridge in the usual way. Pressure was then applied by a known number of turns, or parts of a turn, of the fine screw, and the change of resistance noted. The screw was then brought back to its former position and the pressure relieved, so as to allow the elasticity of the carbon to act, and restore the points to their first condition. It is obvious that, if the change of resistance were due merely

* From *Proceedings of the Royal Society*, Edinburgh.

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to elastic yielding, it should now be the same as before. This I found not to be the case. From the gritty nature of the carbon, the points of contact I found were perpetually changing, and hence the variation of resistance produced in this way obeyed no regular law.

From this irregularity it is impossible, I think, to conclude that this cause could explain the transmission of musical sounds, far less articulate speech.

As far as my experiments go, the following appears to be something like the true explanation of the microphone action: —What I have termed the air and the tremor effects take place simultaneously. The tremor effect produces a jolting of the carbons, sufficient to allow momentary minute elastic arcs to take place between the points, which are just clear of contact with each other. Simultaneously with this the air effect comes in, and on account of the variations of density due to the condensation and rarefaction of the air, acts upon the minute electric arcs so as to vary their resistance. The tremor effect explains merely the production of the musical pitch of the sounds heard in the telephone, whereas it is to the air effect that we must look for the transmission of the quality of the sounds uttered into the microphone transmitter.

The microphone is thus so far a delicate make and break analogous to the old Reis transmitter, with the important addition, however, of momentary gaps filled with a material which is sensitive to the harmonic variations of the atmosperic density which constitute sonorous vibrations.

CORRESPONDENCE.

LAMPS FOR CARRIAGES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to your correspondent, "W. W.," we beg to say that the electric lighting of a two-horse carriage is quite feasible. We have not merely electrically lighted a tricycle, but we have taken a box containing three accumulators, each weighing 14lb., in a hansom cab, in railway carriages and elsewhere, and with it we have kept three incandescent lamps burning. But for the present difficulty of obtaining incandescent lamps which will work with a small electromotive force we might have fed six lamps with the same box instead of the three, which were all we could purchase. The lamps in question are two-candle Swan lamps, each of which will work up to four candles with only a small electromotive force. Within a short time we expect to be able to work a reading lamp with an accumulator weighing only a few pounds.

We may mention also, for the benefit of those who like to read in bed, that we have found the above-mentioned portable accumulator box and one of the incandescent lamps very convenient, as all risk of fire, the bugbear of the burner of the midnight oil, is avoided by their use.—Yours, &c.,

AYRTON AND PERRY.

The Faure Electric Accumulator Company, 71, Queen-street, Queen Victoria-street, E.C., Nov. 22, 1882.

ELECTRIC TRICYCLES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent "Chancery Lane," I have great pleasure in informing him that the motor used by me in my "Legal" Electrical Tricycle is a new arrangement of the "Piot Motor." The apparatus, including a specially constructed battery, is very simple and light, it can be attached to an ordinary tricycle, and will not cost more, I should think, than £10 to £12.—Yours, &c,

JNO. MACDONALD, C.E.

5, Southampton-buildings, Holborn, London, Nov. 21, 1882.

LITERATURE.

THE BATTERY AND THE BOILER.*

The publishing season is now in full swing, and if the east wind, bringing snow and ice in its wake, did not tell us that Christmas was at hand, the books which are issued for amusement and instruction would inform us. Mr. R. M. Ballantyne is well known as a successful writer of tales for the young. His books are always readable, and in many of them, if not in all, he manages to combine a good deal of instruction with lighter reading. One feature in his works is deserving of the highest praise—it is that there is nothing in them which the parent may not safely allow his children to read, without fear of exciting the imagination with deeds of horror, or weakening the moral principle. Mr. Ballantyne takes advantage of the great interest now felt in electrical subjects to construct a story which dwells considerably upon electrical matters. The hero is born at sea, during a terrible thunderstorm. He grows up inquisitive, and especially so in all that concerns electricity, and luckily has a cousin who is able to direct his inquiries. By and bye he is found plodding away in an office, doing his duty manfully, but taking every opportunity to increase his knowledge. His employer recommends him as secretary to one of the electricians on board the "Great Eastern" during her Atlantic cable laying expeditions. The author has the opportunity of describing the operation of cable manufacture at the Construction and Maintenance Company's works at Greenwich, the operations of laying and picking up the cable he relates most graphically, the difficulties encountered and surmounted, the hopes and fears of those on board, and the ultimate success of their work. The hero, after the completion of his work in the Atlantic, goes eastward on a cable expedition, is wrecked, is saved with three friends by means of a raft, thrown on to an island which proves to be the rendezvous of a horde of pirates. What adventures he meets with here, how he escapes and joins the "Great Eastern" at Bombay, taking part in the cable laying between India and England, *viâ* Aden, &c., must be gathered from the book. Suffice it to say that the story, though in some parts a little far-fetched, carries the reader with it to the end, where it will be found that the characters marry and are given in marriage, and, we suppose, live happily afterwards.

We trust that this book may be selected by many a parent and friend for a Christmas present, inasmuch as it will undoubtedly tend to interest the reader in the application of electricity. Pleasure and profit will go hand in hand, for, with one or two slight exaggerations, the statements made in the book will not have to be contradicted by future reading; they are accurate, and have evidently been carefully selected.

DISPLAY OF AURORA.

On Friday and Saturday last, Nov. 17 and 18, a very severe magnetic storm was experienced in our islands, all over Europe, and also in America. We give the following extracts from various newspapers describing the storm and its effects.

The *Scotsman* of Nov. 18, says:—"The weather in Edinburgh yesterday was calm and fine, with light haze in the lower atmosphere and a serene sky, diversified with patches of cloud. Just after sundown, there commenced a splendid display of aurora borealis, a concomitant, no doubt, of a great magnetic storm which yesterday produced such extensive derangement of telegraphic communication, and which certain observers would seem to associate with a remarkable development of sun-spots now in progress. At first, the aurora presented a purplish glare, brightest in the west, but shooting out in broad bands right across the heavens. The appearance of the western sky was, indeed, at one time, such as to give many the impression that a

* *The Battery and the Boiler; or, Adventures in the Laying of Submarine Electric Cables.* By R. M. BALLANTYNE. (Illustrated.) [James Nisbet and Co., 21, Berners-street, London.]

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serious fire must have broken out in the outskirts of the city. As the evening wore on, the phenomenon continued with a varying brilliancy, which would have been even more striking but for the seven-days-old moon that shone in the south-west. A vast expanse of diffused radiance showed from behind a dark cloud-bank that covered a considerable portion of the northern heavens, while ever and anon broad pulsing rays of pale greenish light shot upwards as far as the zenith. The display, as a rule, was most vivid in the north-west, but at times the whole northern half of the sky was brightly illuminated. After nightfall sharp frost set in. Our Kirkwall correspondent, telegraphing at 7:45 last night, says :—To-night, shortly after darkness set in, there was a very unusual display of aurora borealis here. The sky all round turned very red, shortly afterwards pink, and then yellow. The shooters, instead of going up towards the zenith, ran along the sky from east to west, and the different colours diffused were very pretty. Shortly afterwards the sky to the south became very hazy. The barometer is falling briskly—29·32; wind south-west. The aurora to-night was in the south, and attracted the attention of all. The weather is extremely cold; the frost this morning was severe. Yesterday's magnetic storm appears to have been the most remarkable experienced for many years, and it led to a serious delay in the telegraphic service. The earth currents on the Post Office telegraph lines first appeared about 10 a.m. yesterday, almost simultaneously on the east and west and north and south circuits. This is very unusual, for it is but seldom that such currents affect lines running east and west, but it will be observed that the rays of the aurora last night were projected in this direction. These currents varied very rapidly both in strength and direction all day, with the exception of two hours, from 1 to 3 p.m., when they were absent. After that time they again increased in intensity until 11:30 p.m., when they slightly abated in strength, though they continued as variable as ever in direction, and, singularly enough, they appeared to affect the east and west lines to a greater extent than those running north and south. Where the number of wires and other circumstances admitted, 'looping' (*i.e.*, metallic circuits, without earths) was successful, although, as is well known, more power was required to obtain the same telegraphic speed. It may be mentioned that on Thursday there was a brief appearance of magnetic disturbance, but it lasted only for an hour or two. Where the wires could not be looped yesterday, the ordinary circuits were entirely stopped when the earth currents attained a certain force, and for a time they reached a maximum of about 60 volts."

The aurora was also seen in great beauty, both in London and the provinces. Letters from Dover, Sidmouth, Cirencester, and news from all points of the compass, testify to the vividness of the display. It may be noted here that a very large group of spots was on the sun on Wednesday, and on Thursday it was not far from the centre. This group was composed of six spots, and was easily distinguishable by the naked eye. It is the largest group that has been seen for many years.

Mr. E. J. Creese, of Cirencester, who examined the aurora with a spectroscope, gives the following account of his observations :—"The usual yellow-green line was constant, showing strongly, and with the slit of the spectroscope opened a little wider a bright line appeared in the red when the instrument was directed to the more luminous streamers. I also several times saw a fainter line in the indigo. About ten minutes past six two or three faint bands of light appeared in the green and blue parts of the spectrum. The bright yellow-green line showed plainly whenever the spectroscope was directed to the north and east, but in no other part of the sky."

On the Wednesday preceding this auroral display, a very heavy fall of snow was reported as having taken place over a wide area of the British Islands, accompanied by a severe gale, particularly in the south.

The following accounts were received from the United States : —The *Daily News* New York correspondent, telegraphing on Sunday, says :—"A remarkable electric storm, extending the entire width of the continent from Boston to San Francisco, prevailed during Friday night. At Omaha the aurora borealis was so brilliant that night was made as light as day. At Cheyenne, Denver, and at points in California and Washington territory there were similar displays. At St. Paul, Minnesota, the sky was of a blood-red colour, making an effect at once grand and fearful. Telegraph communication was seriously interrupted, and various experiments were tried to work the wires, without success, until it was discovered that by taking two wires from the ground between two given points, and joining their ends a circuit was formed that could be worked. In this way eight wires were made to do the service of four. Electricians agree that the disturbance was unlike any heretofore experienced, as it appeared to act upon the wires in strong waves, constantly changing polarity of current." The *Standard* correspondent says:— "An electric storm, the widest and severest ever known, has swept from New York West to Omaha and Kansas City, and northwards as far as the telegraph goes. Messages were almost entirely stopped. The successive negative and positive waves of the current passed from east to west, alternately intensifying and neutralising the battery current, and the instruments were repeatedly fused. At Nashville the galvanometer varied 80degs. Bangor worked a message a distance of 700 miles without a battery. At Milwaukee, by means of the storm alone, an electric light requiring eight horse-power was kept burning for some time. The auroras were very remarkable." *The Times* correspondent adds the information that "cold weather, with snow, accompanied the storm in many places."

From the Continent we learn, through the *Daily News*, that "M. Flammarion, the well-known astronomer of Paris, received a telegram this morning (Thursday, Nov. 17) from M. Bruguière, at Marseilles, informing him that there is at the present moment a quadruple spot on the sun's surface, visible to the naked eye, and of far greater size than the earth. Magnificent aurora boreales are again reported from Norway. Strange to say, this is the seventh time this year that the northern lights have made their appearance simultaneously with the presence of enormous spots on the sun's surface." The *Standard's* Berlin correspondent says, telegraphing on Friday night :—"Winter commenced here last night in earnest. This morning all the streets of the capital were found covered with snow, which up till evening showed no symptoms of melting again. This is full early for winter in Berlin. One of the worst inconveniences of the storm is the interruption of most of our chief lines of communication, both railway and telegraphic, with places at a distance. We have since mid-day been cut off from London, Paris, St. Petersburg, and Cologne. This, however, is, I find, attributed by meteorologists chiefly to a violent electric disturbance, which has prevailed simultaneously with the snowfall." The *Daily Telegraph* of November 18 says that their special wire to Paris was interrupted. A message from their Vienna correspondent on Thursday night says :—"In consequence of an occurrence of northern lights, telegraphic communication with and from Vienna has been interrupted to-day. It has been a dull, rainy day, and my thermometer stands at three and a-half Réaumur, whereas the last observation of northern lights in Vienna was in the middle of summer."

PARISH OF ST. PANCRAS.

Like many other authorities, the St. Pancras Vestry has recently been investigating the position of the electric light, and the Lighting Committee has just received a report on the subject from their clerk, Mr. T. E. Gibb. This gentleman points out that the consideration of the subject has been forced upon the authorities by recent legislation, and, among other things, remarks that :—

The electric light has now, it is considered, passed the experimental stage as regards its efficiency, and although undoubtedly improvements will be made from time to time, the only serious subject of consideration is the cost. The duties of an authority under a license or provisional order, after taking steps to protect itself, will be simply to supply electricity, and such authorities will not have to concern themselves as to the merits or demerits of any particular lamp or burner, or even as to the purposes to which the electricity may be applied. The electricity will be supplied by meter. The safety of the householder will have to be secured by some means. Dr. Hopkinson, in his evidence before Mr. Chamberlain's committee, said that with a fusible point any undue quantity of electricity will be prevented from passing the point, and that with it "you can make the thing absolutely safe." The plan is to introduce a short length of lead into the main conductor entering the house; this lead has a carrying capacity sufficient for the largest current which the lights in that house can require, so that if by any mischance the amount of electricity supplied should be in excess of the requirement, so as to produce risk of accident from the heating of the conductor, the piece of lead would be fused and fall, thus interrupting the circuit, and cutting off the supply. The introduction of fusible points for the purpose of securing safety in the event of the electromotive power or pressure being excessive need not in practice be limited to the point of the introduction of electricity into a house. Mr. Edison has introduced these points as frequently as desired, and they can be fixed to each light, if thought safer, by means of safety plugs, which interrupt the copper conductors with a piece of lead wire, and if the current be broken by fusion, and a light or series of lights, as the case may be, put out, the current can be connected again by simply inserting a new plug. Electric light, whether considered as to efficiency as a means of artificial light or as to cost, must be a matter of interest to the vestry even so far as it is a question of general public interest; but it is especially important to the vestry as a local authority, because its extensive use involves an interference with the control of the public streets. At the same time it interferes with the vested interest of established companies heretofore entrusted with the supply of gas, or with municipal authorities who have themselves undertaken to supply gas in their districts. It has been laid down as an axiom in connection with the introduction of the electric light that, although there are gas monopolies the rights and duties of which must not be ignored, there is no monopoly of artificial light. I have before referred to the fact that the local and other authorities who may be entrusted with the supply of electricity are not to concern themselves as

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to the manner of its application except so far as may be necessary for the protection of the general interests of such authorities.

Electricity is dealt with by the Act of Parliament not as for lighting purposes only, but as a "source of power and light." The Act contemplates that by means of accumulators electricity may be used for many purposes. Such accumulators have been used already for storing electricity for lighting large rooms, for lighting the passenger steamers from Newhaven to Dieppe, and the Pullman express from London to Brighton. The extent of the use of accumulators is yet but little known, and it is said that by their use the electric energy can not only be stored for purposes of lighting, but for motive power (such as the working of tramway cars and omnibuses), the propulsion of electric cars (as a substitute for cabs), tricycles, &c., the driving of lathes, printing presses, sewing machines, and other small machines, elevators, and pumps, &c. This possible extension of the uses of electricity makes the subject more important to a local authority than even the great question of public and private lighting. . . . . It may be observed here that if a municipal authority be entitled to receive at the hands of Parliament a protection because it has fulfilled its duty, then a private company may also be entitled to similar protection in a district such as St. Pancras. The reasons for such protection being claimed on behalf of the local authorities who have the supply of gas in their own hands are such, however, as should lead the vestry to be extremely careful in guarding the public interests in the streets.

The Electric Lighting Act seems to assume:—1. That great progress has been made in the subject of electric lighting. 2. That this progress warrants Parliament affording facilities for the introduction of the system. 3. That it is more desirable in the public interest that the authorities entrusted with the care and control of the public streets should be responsible for the supply of electricity than that such responsibility should be entrusted to private companies. 4. That where for any reason the local authority is not disposed to take the responsibility of supplying electricity, those who require it should still have the power to obtain it on the most advantageous terms, and that therefore facilities should be given for private companies to afford such supply where a reasonable demand may be made for the same. 5. That where power to supply electricity is given to a private company, the local authority should be empowered subsequently to take over the responsibility from the Company.

It must be admitted that electricity can never be supplied economically unless supplied over a large area. Several witnesses examined before Mr. Chamberlain's committee concurred in the opinion that a fair experience as to the economy of the electric light could only be made in a limited district covered by a population of say 50,000. The vestry will at once admit that under such circumstances the supply of electricity should be placed under some such parliamentary control as is now provided. It is quite clear that "over head" wires for private supply are a source of danger and inconvenience, even only to the limited extent that they are at present in use, and therefore any extensive use of electricity must involve a disturbance of the public streets.

By Rule 2 of the Board of Trade, made under the Electric Lighting Act, it is provided that, when applications for provisional orders authorising the supply of electricity within the district of any local authority are received by the Board of Trade from such local authority, and also from any other authority, company, or person, the Board of Trade will give a preference to the application of the local authority of the district in every case where, in the opinion of the Board of Trade, no special circumstances exist which render such a preference inexpedient. This rule does not provide for a preference to the local authority in case of application for a license. The omission may be accidental, but it leads to the question as to the difference of the value of a license as compared with a provisional order. The rules of the Board of Trade require much the same formalities for a license as for a provisional order, and objections may be made to each. The chief difference seems to be that as a provisional order requires confirmation by Parliament, it is open to be opposed in the same manner as a parliamentary Bill, and the cost of such an opposition in all probability would exceed the cost of an opposition before the Board of Trade. One reply to this is that the probabilities of opposition are remote, seeing that it has already been decided that preference is to be given to the local authorities. Of course, if a local authority took up the question merely with a view of keeping private companies out of the district, and without any *bonâ fide* intention of dealing with the subject, a parliamentary opposition, or an opposition before the Board of Trade would no doubt be effective, but if the vestry take up the question with a *bonâ fide* intention of doing what is best to be done under the circumstances, I think a provisional order could be obtained without fear of opposition and at a very small cost. Moreover, I think the vestry would be in a better position, having a provisional order rather than a license to contract under the provisions of the Act with "any company or person for the execution and maintenance of any works necessary for the supply of electricity." It will be observed that the license shall be for a period not exceeding seven years, and can only be renewed if given to a company subject to the consent of the local authority, while there is no limit of time for which a provisional order may be granted. It is provided by Section 27 of the Act that where any private company is authorised by a provisional order or special Act to supply electricity within any area, any local authority may, within six months after the expiration of 21 years, or a shorter period if such be specified, require such company to sell their undertaking upon terms of paying the then value of all lands, buildings, works, materials, and plant of such company suitable to, and used by them, for the purposes of their undertaking. To be in case of difference determined by arbitration.

The following applications for consent to the granting of a license under Section 3 have been received:—The Jablochkoff Electric Light and Power Company, Metropolitan (Brush) Electric Light and Power Company.

The following notice of application for provisional orders under Section 4 have been received:—Metropolitan (Brush) Electric Light and Power Company, the Gülcher Electric Light and Power Company, the Edison Electric Light and Power Company, the West Middlesex Electric Lighting Company, the "Pilsen," "Joel," and General Electric Light Company; the "Ferranti, Thompson, and Ince" Company; the Swan United Electric Light Company.

Upon these applications and notices, the first question that arises is whether the vestry will apply for a license or a provisional order to supply electricity in St. Pancras. If the vestry are so disposed they can afterwards arrange for carrying out the scheme with one or more of the electric companies. It is necessary, however, before obtaining either a license or a provisional order that definite general arrangements should be made, inasmuch as the Board of Trade require before considering any application that full particulars shall be given. If the vestry decide to apply for a provisional order they should be well advised as to the details of such order by some practical electrician, the object of such advice being so that the vestry may secure in their order all powers which may now or hereafter prove valuable, and at the same time guard themselves from unnecessary obligations. This is the more necessary as very much has been said for and against the many points associated with this subject by persons whose judgment and experience does not warrant them in offering advice. I believe there are several persons of eminence as electricians who are prepared to afford assistance to local authorities, amongst them Dr. Siemens, Sir William Thomson, Professor Jenkin, of Edinburgh; Dr. Hopkinson, and Messrs. Clark and Muirhead.

The general obligations which would be imposed upon the vestry in a provisional order are contained in Sections 11 and 19 of the Act, which are as follow:—Section 11: Any local authority who have obtained license, order, or special Act for the supply of electricity, may contract with any company or person for the execution and maintenance of any works needed for the purposes of such supply, or for the supply of electricity within any area mentioned in such license, order, or special Act, or in any part of such area; but no local authority, company, or person shall by any contract or assignment transfer to any other company or person, or divest themselves of any legal powers given to them, or any legal liabilities imposed upon them by this Act, or by any license, order, or special Act without the consent of the Board of Trade. Section 19: Where a supply of electricity is provided in any part of an area for private purposes, then, except in so far as is otherwise provided by the terms of the license, order, or special Act authorising such supply, every company or person within that part of the area shall, on application, be entitled to a supply on the same terms on which any other company or person in such part of the area is entitled under similar circumstances to a similar supply. These general obligations may be considerably modified or altered by the provisional order, and while there is no doubt that such an order would contain conditions in which a supply could be demanded by any person within the area of supply, it is nevertheless believed that these conditions will be guarded by provisions similar to those contained in the Gas Works Clauses Act, so that a local authority would not be compelled to supply at a loss.

Mr. Farrer, the Permanent Secretary to the Board of Trade, in his evidence upon the reasons which led the Board of Trade to prepare and introduce the Electric Lighting Bill, speaking with reference to the obligations to be imposed on the authorities who may undertake to supply electricity, intimated, with reference to the provision of Section 19, "except in so far as is otherwise provided by the license, order, or special Act authorising such supply," that these words would depend for their meaning entirely upon the terms of the order or license, "because the thing is so new that it would not be desirable to tie the authorities too tightly." No doubt, therefore, although there will be a disposition to impose such conditions upon the local authority as will secure a *bonâ fide* attempt to carry out the provisions of the Act, at the same time there will be such protection as the circumstances necessarily demand, so that the obligations imposed, at least, in the early provisional orders, will not, probably, be so onerous as some persons contemplate. If the vestry obtain a provisional order, it will be quite competent for them to contract with one or more companies to supply electricity, and in such a case the vestry's obligations would not, probably, exceed those which they have as a sanitary authority or road authority, where the vestry take care to insert in their contracts clauses providing for indemnification by the contractors against any damage, by way of compensation or otherwise, which the vestry may become liable to pay, as the authority primarily responsible.

There is one advantage, I think, specially in favour of the vestry of St. Pancras taking up the new powers for the purpose of lighting. It is that, if the vestry were to commence operations in an area, say a mile square, and taking a spot near the junction of Tottenham Court-road and Euston-road as the centre, they would be able to light the three great railway stations and hotels of the London and North Western, the Midland, and Great Northern Railway Companies, the Metropolitan Railway, University College and Hospital, the Vestry Hall, as well as many large establishments such as Shoolbred's and Maple's. Such an area of a mile square would be a fair one to test a complete installation, as regards economy. The cost of such an installation might be, according to the evidence given before the committee of last session, about £200,000 for 50,000 lamps, or about £4 per lamp. There would probably be no difficulty in securing a contract with a good company who would embark the necessary capital with such customers as those named. If there is any probability of the vestry applying for a provisional order, notice thereof must be given without delay, although the giving of the notice will in no way commit the vestry to proceed further. If the vestry decide not to apply for powers either by provisional order or license, then I think the committee should be authorised at once to put themselves in communication with the companies from whom notices have been received in order that the vestry may secure in any license or order to be obtained all necessary provisions for the purpose of giving the vestry full control over the streets (and, if possible, power to contract with the lighting companies to execute for such companies any works which may involve the disturbance of the streets), as well as power to secure the adoption of suitable central sations; for the supply of electricity to the public lamps; for limiting the period of concession; and for purchasing the rights of the company afterwards if the vestry should see fit so to do.

In conclusion, it may be observed that there is nothing in the Electric Lighting Act to prevent electric lighting companies or private persons from supplying any place they choose without any parliamentary powers whatever, provided they can do so without breaking up the streets. The Act does not take away any powers which existed in this respect before it was passed, but simply refuses in the interests of local authorities, to furnish companies with a new privilege of breaking up streets without the assent and concurrence of the local authority, or, at all events, without the local authority having had full opportunities of objecting to the application for such powers, and of putting forward their own *primâ facie* preferential claim. Upon this it might be remarked that the vestry have already

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granted permission to private persons to disturb public streets, for the purpose of laying down electric wires. It is a question whether such an act on the part of the vestry was not *ultra vires*, and it is very probable, now that parliamentary action has been taken, that objection would be made to the vestry granting such a permission in the future otherwise than in accordance with the provisions of the Electric Lighting Act.

(Signed) THOS. ECCLESTON GIBB.

BIRMINGHAM AND WARWICKSHIRE BRUSH ELECTRIC LIGHT AND POWER COMPANY.

A special general meeting of this Company was held at the City Terminus Hotel on the 22nd inst., under the presidency of Mr. G. M. Felton.

The CHAIRMAN stated that the meeting had been convened consequent on the action of certain shareholders. The directors considered that this action was inimical to the interests of the Company, and that if persevered in it would probably ultimately be ruinous to them. At their last meeting he gave them a *resumé* of the Company's business. They were then in negotiation with several large towns, and they had a contract at that time which he then informed them was about to be signed. That contract, which was for an installation of 40 lights, had been signed, and the lights were either now running or would be in a day or two. They were also at the same time in negotiation with several works to put up the electric light for manufacturing purposes. A circular then appeared from Mr. Whiteley, and about the same time Sir Charles Bright's letter was published, showing that the British Electric Light Company had, concurrently with the Anglo-American Brush Company, the right to use the Lane-Fox incandescent lamp. This statement came on the Board as a surprise, and they were blamed for not having taken proper precautions in looking through the agreements before the prospectus was issued. When the prospectus was issued, it was lodged with the Company's solicitors. They looked it through. The Hammond Company looked it through, and passed it: and the Anglo-American Brush Company looked it through, and it was returned to the Company. Thus this Company *bonâ fide* purchased the exclusive rights to the Lane-Fox lamp. The directors still hold that opinion, and they asked the shareholders to support them in it. At that time Messrs. Ingledew and Ince were the Company's solicitors, and feeling that it would be more satisfactory to the shareholders, inasmuch as those gentlemen were also solicitors to the vendors, the directors placed the matter in the hands of Messrs. Linklater. On the very day that Mr. Whiteley's first circular was sent round the directors had a circular printed, and the envelopes addressed, for calling the shareholders together, and asking their opinion as to the course to be taken with regard to Sir C. Bright's letter. They submitted that circular to Messrs. Linklater. They were then in negotiation as to the repurchase of the Lane-Fox license, and they did not issue the circular, thinking that in a few days they would bring the negotiations to an end, and be able to place before the shareholders something tangible which would put the Company in a much better position. He would remind them that by the Electric Lighting Bill the consumer could use any lamp he pleased. Mr. Whiteley's circular contained many statements which were the reverse of complimentary, and he had issued similar circulars to other companies in which he held a few shares. He had stated that there were numerous actions lodged against this Company. The writ, however, which Mr. Whiteley referred to was lodged by himself, and a gentleman, named Sprangue, had petitioned. There was no other action at that time but that of Mr. Whiteley. It was not the case that any shareholder in this Company had had a penny of his subscription returned to him. Immediately he heard of the action taken by Mr. Whiteley he ordered the business they had in view to be set on one side, stating with respect to the Company's money at the bank that not a penny of it should be spent on plant till this matter was settled. Much had been said respecting the retirement from the Board of Mr. Evans and Captain Inman. The latter gentleman, however, attended their meetings only twice, and as he came up from Liverpool for the purpose he was evidently put to considerable inconvenience. He gave reason for resigning. Mr. Evans did give a reason. The directors were at that time negotiating for the repurchase of the Lane-Fox license. They differed about the amount, and Mr. Evans could not go with them. Consequently he resigned, and nothing could have been more straightforward than the conduct of that gentleman. He himself had felt at the time that he should like to resign, but he had seen on reflection that he should not be doing his duty to his friends if he had taken that course. The Company had now every prospect of doing a fair business. Negotiations had again been opened that day with the vendors, and they had an offer by which very nearly one-third of the capital would be returned to them. Their capital was now about £75,000 or £76,000; and if they had to pay a dividend, that could be done better with a capital of £50,000 than with a capital of £75,000. He asked the shareholders to support the directors in these negotiations, and they would come to no terms unless they were agreed to by the shareholders. As to winding up the Company, he did not know the reason for such a suggestion. He asked them to support the directors in the shareholders' interests. When the negotiations to which he had referred were completed, a circular would be sent to them; and he thought they would then have a very fair prospect of a good business in front of them.

Mr. RATCLIFF moved, "That it is the opinion of this meeting that the recent litigation which has been commenced is most prejudicial to the true interests of the company, and every opposition should be offered to all the hostile proceedings against the company."

Mr. THOMAS BEARD seconded the motion.

Mr. HAMMOND, in supporting the resolution, stated that he did not wish to introduce one discordant note into the proceedings, but he could not allow to go unchallenged the statement that the Hammond Company passed and approved the prospectus of this company. It was true that the prospectus of this company was submitted through the Hammond Company to the solicitors of the Brush Company, but he maintained that the Hammond Company where in no way liable in the matter. The Hammond Company passed on their license word for word as they received it from the Brush Company.

Mr. D. EVANS supported the resolution, and in doing so explained the circumstances of his resignation. He had been of opinion at the time that a full claim should be made upon the Hammond Company for the mistake referred to; but his co-directors were then in favour of a compromise. Nine days after his resignation, however, he found that the directors were pursuing the very same mode of attack on the Hammond Company which he had recommended.

Mr. INCE disclaimed any liability on the part of his firm for having approved the prospectus of the company. The prospectus was prepared by the promoters, and his firm had nothing to do with it. He held, too, that no one had taken shares in the Company on the strength of the statement complained of—that the Company had exclusive rights as to the Lane-Fox license.

The resolution was put and carried.

The Hon. R. MOLYNEUX then moved, and Dr. MACKENZIE seconded, the following resolution, which was carried:—"That the chairman having reported to the meeting that negotiations were pending with the various parties interested, with a view to an amicable arrangement of the difficulties with reference to the Lane-Fox light, be it further resolved that, in the opinion of this meeting, it is desirable that an amicable arrangement of the nature suggested should be come to, with a view to the carrying on of the business of the Company, and that the terms of any arrangement should be submitted to the shareholders for their approval before the same is finally concluded.

A vote of thanks to the chairman terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES Nov. 22.		BUSINESS DONE WEEK ENDING NOV. 22. Highest.		Lowest.	
Anglo-American	46½,	47½	.....	—	.....	—
Do. Preferred	77,	78	.....	78¾	.....	78
Do. Deferred	17,	18	.....	18	.....	17½
Brazil Submarine	11¾,	12	.....	12	.....	11¾
Cuba	9½,	10	.....	10	.....	9½
Do. Preference	16,	17	.....	—	.....	—
Direct Spanish	7,	7½	.....	7½	.....	6¾
Do. Preference	16,	17	.....	16¾	.....	16¾
Direct United States Cable	11½,	11¾	.....	11 7-16	.....	11¼
Eastern Telegraph	10½,	10¾	.....	10¾	.....	10⅝
Do. 6 per Cent. Preference	12¾,	13¼	.....	13¼	.....	13
Do. 5 per Cent. Debentures, 1899	103,	106	.....	—	.....	—
Eastern Extension	11⅜,	11⅝	.....	11⅝	.....	11⅜
German Union	10,	10½	.....	10½	.....	9 15-16
Globe Telegraph and Trust Company	6½,	6¾	.....	6¾	.....	6 7-16
Do. Preference	12¼,	12½	.....	12½	.....	12¼
Great Northern	12½,	12¾	.....	12 9-16	.....	12 9-16
Indo-European	30½,	31½	.....	—	.....	—
Mediterranean Extension	1½,	2	.....	—	.....	—
Do. Preference	7½,	8½	.....	—	.....	—
Reuter's	12½,	13	.....	—	.....	—
Submarine	245,	255	.....	254	.....	253
West India and Panama	1½,	1¾	.....	1 7-16	.....	1⅜
Do. 1st Preference	7,	7½	.....	7½	.....	7
Western Brazilian	7½,	7¾	.....	8	.....	7⅞
West. Union 7 per Cent. 1st Mortgage	121,	124	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	100,	103	.....	101½	.....	101½

TELEPHONES.

Consol. Telephone and Maintenance	1,	1¼	.....	1¼	.....	1 1-16
Oriental	⅛,	¼	.....	¼	.....	⅛
United Telephone	10½,	11½	.....	11½	.....	10½

ELECTRIC LIGHT.

Anglo-American Brush	10½,	11	.....	11 9-16	.....	10½
Maxim-Weston	⅜,	½	.....	½	.....	7-16
Eastern Electric	2,	2½	.....	2½	.....	2

TRAFFIC RECEIPTS FOR OCTOBER, 1882.

COMPANIES.	Oct., 1882.	Oct., 1881.	Increase.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,000	2,192	—	192
Direct Spanish Telegraph Company	2,079	2,063	16	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	29,925	31,164	—	1,23
Eastern Telegraph Company	58,173	48,872	9,301	—
Great Northern Telegraph Company	21,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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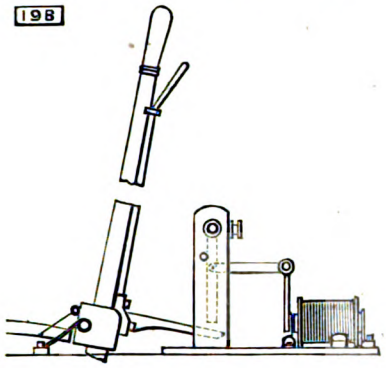
RECENT INVENTIONS.

ABSTRACTS OF SPECIFICATIONS.

198. IMPROVEMENTS IN ELECTRIC BLOCK SIGNALS AND ELECTRIC LOCKING APPARATUS FOR LEVERS WORKING SEMAPHORES AND POINTS ON RAILWAYS, &c., *J. Radcliffe, Retford, Notts.*—*13th January*, 1882. 6*d*.

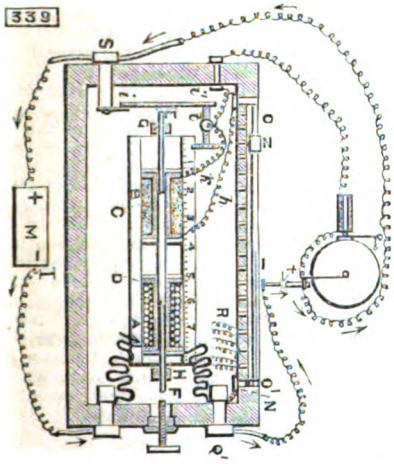
The object of the invention is to prevent the signalman from lowering his signal until he has



received "line clear." The signal lever is locked by means of a vertical bar suspended from its upper end over a projecting tongue, attached to and forming part of the clip lock of the lever. A link attached to the armature of an electro-magnet is connected with the bar as shown in the figure. The electro-magnet is connected with the block signalling instrument at the station in advance, and in such a manner that a current is only passed to the magnet when the instrument is at "line clear." When the current passes, the electro-magnet attracts its armature, draws the bar free from the projecting tongue of the lever clip lock, and the signalman is able to move the lever. In addition to the above the inventor claims a block-signalling apparatus.

339. IMPROVEMENTS IN REGULATING ELECTRIC LAMPS, &c., *E. de Pass, London.*—*23rd January*, 1882.—(*A communication from B. Abdank, commonly called Abakanowicz, Paris.*) 6*d*.

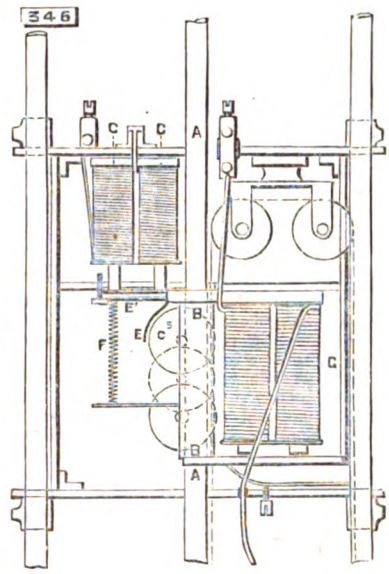
The principle of the invention is the introduction of a resistance balance, as the inventor calls



it, into the circuit of the lamp, which measures the resistance of the arc. The figure illustrates, in section, one form of this balance. A and B are two movable solenoids, one in the main circuit, the other in a shunt. Through these passes a core C D, having non-magnetic extensions C E and D F, which slide freely in bearings G H. The main current passes from terminal I of the machine M by Q, coil A, and Q^1 to the lower carbon of lamp. The derived current is taken from Q^1 through terminal N; it then traverses resistances R—only a portion of which are shown—in the box, enters a movable indicator Z—travelling over a graduated scale—and passes through rod O O^1, traverses *h h*, enters shunt solenoid B, and out through wire *k* into *t*, rod *i i* held by a weak spring, and terminal S. By this means a resistance interposed in the circuit can be measured. Suppose that on the introduction of such resistances C D approaches solenoid B; if then, by means of Z, additional resistances P R be inserted in the circuit of B, the attraction of A will become greater than B, and C D be attracted that way, so that by adjusting Z an equilibrium will be produced, and the resistance required to produce it be ascertained. Moreover, A and B are movable on a slide, and their position with regard to C D changes their attractive force upon this core. This reciprocal motion, indicated on the graduated scale of the slide, in combination with a short travel of C D, also allows the resistance introduced into the main circuit to be measured.

346. IMPROVEMENTS IN ELECTRIC LAMPS, &c., *R. E. B. Crompton, London.*—*24th January*, 1882. 8*d*.

This relates to improvements in arc lamps. The action of the lamp will be understood by reference to the figure, and the following explanation. When no current is passing the gearing frame B B rests within the main frame in its lowest position, the rack rod A A being free to descend through it until stopped by its carbon resting on the lower carbon. When the current enters the lamp it passes through the helix of the main magnet G, lifts the frame B B, and with it the rod A A through its proper stroke, thus parting the carbons and establishing the arc. When thus lifted the frame B B brings the soft iron end E^1 of the brake E within the attractive influence of the fine wire feed magnets C C. So long as the



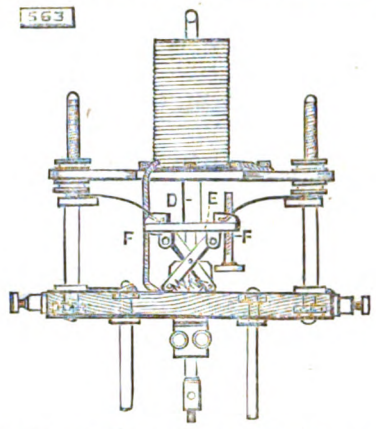
difference of potential at the two sides of the arc remains normal, the current through C C is only sufficient to give it attractive power to balance the opposing regulating spring F which presses the brake E on brake wheel C^3. When the difference of potential exceeds that for which the regulating spring is regulated, the feed magnets overcome the spring, lift the brake off the brake-wheel, and allow the rack rod A A to descend until the difference of potential is again normal. An improvement consists in the provision of a long fine wire of high resistance, in connection with, say, the positive terminal of the lamp and earth, the object being to provide a leakage wire for the static charge which is acquired by the lamp. Another improvement consists in an arrangement for cutting the lamps out of circuit.

378. SIGNALLING APPARATUS FOR RAILWAYS, *W. P. Thompson, Liverpool.*—*25th January*, 1882.—(*A communication from W. W. Gary, Boston, U.S.*)—(*Not proceeded with.*) 4*d*.

The object is to provide a simple, reliable, and inexpensive signal mechanism for use at crossings, curves, stations, and other places at which audible or audible and visible signals are required to be given; and it embraces the use of a magneto generator or dynamo machine driven by passing trains so as to develop an electric current which is utilised to actuate the signals.

563. IMPROVEMENTS IN ELECTRIC LAMPS, *A. J. Jarman, London.*—*6th February*, 1882. 6*d*.

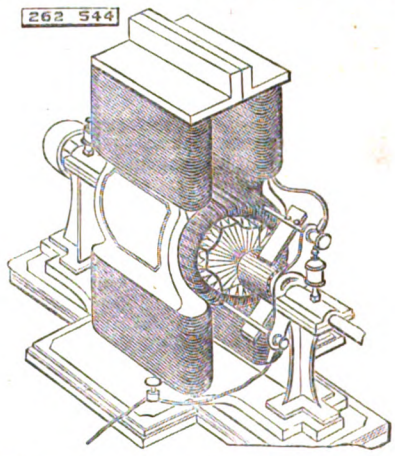
The construction of the lamp will be understood from the figure. The base of the core D is provided with lugs carrying pins, F F, against which slide cross bars, pinned at their centres. When a current flows through the electro-magnet the core is drawn upwards, the cross arms are



straightened and force the gripping pieces against the upper carbon rod, thus lifting it and establishing the arc. The slightest decrease in the magnetisation of the core causes the cross arms to touch the bed-plate, extending them, releasing the carbon road, and so shortening the arc.

262,544. DYNAMO-ELECTRIC MACHINE, *James A. Jenney, Fort Wayne, Ind., Assignor to the Fort Wayne Electric Light Company, same place.*—*Filed April* 15, 1882.

Claim.—(1). The combination, in a dynamo-electric machine, of four electro field magnets, which, with their connecting plates and field segments, are made in two solid continuous masses of iron, so formed and joined in a plane passing either vertically or horizontally through the centre of the armature axis that the field magnets in such casting shall be in line with each other and in the two castings parallel with each other, and which are wound with their field coils in such directions that the two magnets in each casting shall have their similar poles joined in the field segment connecting them, and that the two field segments shall be of opposite magnetic polarity with respect to each other, said two castings to constitute, when joined and bolted together, the entire iron framework of the machine, exclusive of the armature and its mounting, with a cylindrical soft iron armature, smooth and uniform in thickness in surface, mounted and revolving between the field segments aforesaid upon an open skeleton or framework of wood and brass or other non-magnetic material, adjustable in all directions from its central axis, the whole constructed, combined, and operating substantially as described and set forth. (2). In a dynamo-electric machine,



a skeleton or framework for the mounting and carrying of a cylindrical iron armature, consisting of two hubs, made of brass or other non-magnetic material, with radiating arms of like material, adjustable in length by being set as screws into their hubs, and supporting at their extremities wooden bars pressing against the inner surface of the armature, substantially as described and set forth.

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232. An Improved Permanent Way for Electric and Telephonic Conductors, *H. R. Meyer, Liverpool.*—17*th January*, 1882. 6*d*.

The inventor constructs an insulated underground permanent way for wires, by means of blocks or slabs of glass, or glazed or unglazed earthenware rendered moisture proof by dipping in hot asphalte or other suitable substance. The slabs are grooved for the reception of the wires, and laid one over another in layers, each slab being dovetailed into its predecessor and follower.

297. Improvements in Galvanic Batteries, &c., *J. and A. J. Higgin, Manchester.*—20*th January*, 1882. 6*d*.

This invention includes the substitution of tin for the zinc elements in batteries, and a simple means whereby the tin is recovered in a form suitable for certain chemical manufactures. Inside a stoneware jar a hollow cylinder of tin is placed. Inside this cylinder is placed a porous cell. In the outer cell dilute sulphuric acid is placed, and in the porous cell a carbon rod surrounded by pyrolusite or native peroxide of manganese broken small. When in action the sulphuric acid produces proto-sulphates of tin and manganese, which remain in solution. The tin is subsequently separated by adding to the saturated solution sufficient peroxide of manganese in fine powder to cause the protosulphate of tin to become persulphate. The liquid is then diluted largely with water, when a precipitation of stannic acid or oxide takes place. This is subsequently washed, thrown on a filter, drained to a paste, and is then ready for further treatment for chemical purposes.

300. Improvements in Fire-extinguishing and Alarm Apparatus for Use in Theatres, &c., *W. R. Lake, London.*—20*th January*, 1882.—(*A communication from H. S. Maxim, Brooklyn, New York.*) 8*d*.

The invention consists of a circuit-closing device, formed of two metal plates, each forming a spring, and separated from each other by a piece of fusible material insulated from the plates. One of the plates carries a point, and the whole is fixed in the wall or other part of the building. When the temperature reaches a certain height, owing to fire, the strip of fusible material melts, and the plates approach each other and close the circuit, in which is included the following apparatus:—A hammer, the head of which strikes on mechanism for actuating an alarum, the hammer being let loose by the attraction of the armature of an electro-magnet in the circuit. The arm of the hammer at the same time operates a series of levers, which liberate a weight, which in turn acts on a lever which opens a valve, and allows water to flow into a pipe running round the buildings, from whence it can be directed to the seat of the fire. To localise the emission of water, however, at the point where the fire has broken out, the inventor places nozzles at intervals along this pipe, fitted with quick matches, which communicate with a charge of gun-cotton. The explosion of this blows off the cap of the nozzle, and permits the flow of the water. These nozzles are fitted at convenient intervals over the building. By a modification of this arrangement the inventor includes in the circuit an apparatus for producing carbonic acid gas.

305. Impovements in Electric Lamps, *J. N. Aronson, London.*—21*st January*, 1882. 6*d*.

This relates to the construction of the globes of incandescent lamps with reflectors formed of the same material as the globe itself, the reflective surface being produced by silvering, enamelling, or other means.

359. Improvements in and Connected with Electric Lamps, *J. N. Aronson, London.*—24*th January*, 1882. 8*d*.

This relates to incandescent lamps, and has for its object the combining of several carbons, either in one globe or several clusters of carbons in glass tubes in one large globe, so that on the failure of one, another can be substituted for it, and put in circuit either automatically or by hand. One arrangement, when several carbons are used, is to enclose each terminal or connecting wire in a glass tube fused around it, and then to arrange the tubes in a group and fuse them into a mass, which may be fixed in the globe by fusion or like a stopper. The ends of the wires are formed into contact pieces. The socket is provided with contact pieces in connection with the leading wires; these may be either sliding or stationary, and the inventor brings these into contact with the terminals of one of the carbons at a time, either by hand or by an automatic arrangement in connection with an electro-magnet and armature, so that on the failure of a carbon a fresh one may take its place.

361. Improvements in and Relating to Electrical Conductors or Cables, *W. R. Lake, London.*—24*th January*, 1882 ——(*A communication from H. A. Clark, Boston, Mass., U.S.*) 6*d*.

To prevent inductive action the inventor places a body of conductive material of considerable size, relatively to the size of the conductors in the cable, close to the insulating coating of a series of conductors, so that the electric impulses expend their energy on the conducting material. No two conductors, also, are allowed to remain next one another for the entire distance they traverse. The second part of the invention refers to a method for keeping the wires in a cable at their relatively proper distances from each other during the process of vulcanisation.

377. Improvements in Electric Lamps, *Sir C. T. Bright, Bolton Gardens, London.*—25*th January*, 1882. 6*d*.

The figure illustrates one form of the inventor's lamp. The action is as follows:—When the current passes through the two circuits, A A—thick wire electro-magnets in main circuit—draw up sliding frame C C by attracting armature B, at the same time G—and the opposite similar armature not seen in the drawing—being attracted by poles I of fine wire magnets in shunt circuit—grasps hold of carbon holder J J by jaws at F, and rises with it. K is an armature fixed to contract lever L—shown in side view in Fig. 2. K is attracted by the other poles M M of the fine wire magnet, and thereby brings L into contact with N whenever the arc gets too long. L and K are connected to the fine wire magnet, which, being cut out of circuit, cease to attract G, and the carbon holder is free to all. L is, however, at once brought back by spring O to its place of rest, the jaws again grasp J J, and the proceeding is repeated till the arc is adjusted to its normal condition.

386. Improvements in the Construction of Cores for Cables, &c., *W. T. Henley, Plaistow.*—26*th January*, 1882. 6*d*.

This relates to the construction of a core with multiple conductors, which may be used for a number of circuits or a few, a switch connecting all the conductors in one or in separate circuits, from two upwards, according to the direction in which it is turned. The conductors of the core are first insulated separately and then all enclosed in another coat of insulation, being next served with yarn and protected with wires in the usual way. The improvement consists in surrounding the core with strong manilla or Russian hemp laid up into closely spun yarns, which are laid round the core in long spirals and then served with galvanised steel wires of small size; the cable is then covered with tape or yarn and compound as usual.

436. Improvements in Electric Telegraph Printing Apparatus, *J. Imray, London.*—28*th January*, 1882.—(*A communication from J. M. E. Baudot, Paris.*)—1*s*.

This relates to an electric telegraph printing apparatus with multiple transmissions. In this system the sending of a letter includes two operations—First, the transmission by the signal; Second, translation of this signal and impression of the letter. The signals are formed by means of commutator levers, worked either by an operator or automatically by the machine itself. The letters are represented either by the action of a single commutator or by that of several combined. At the receiving station the signals are reproduced by means of movable mechanisms actuated by electrical currents, and corresponding respectively with the commutators of the sending station. The number of transmitting levers and of the corresponding movable receiving instruments depends upon the number of distinct combinations which it is possible to effect with them, and also upon the number of letters to be transmitted. The movements of the movable receiving instruments are communicated at the receiving station to a translating instrument which stores them and effects their translation. During the time employed in translation the line is utilised for transmitting other signals.

441. Improvements in Electric Railways, *C. F. Varley, Bexley Heath, Kent, and W. Judd, Penang, Straits Settlements.*—28*th January*, 1882. 4*d*.

This invention consists of a metal conductor laid in a groove cut in a sleeper, which is rendered non-conducting by being desiccated by superheated steam or hot air, and subsequently impregnated with insulating material, such as paraffin, &c. The sleepers are covered with guard plates fastened on them, which do not entirely close the upper surface of the sleeper, but are so arranged as to leave a space sufficient to allow a roller or rollers connected with the car to make contact with the conductor, so as to convey the electricity from the conductor to the electric motor in the car. The electricity is supplied to the conductor by dynamos at suitable places. Methods for insuring good insulation of the conductor are also described.

489. Improvements in Electrical Batteries, &c.—*G. Skrivanhoff, Paris.*—31*st January*, 1882.

This relates to a "dry" battery, consisting of a plate of retort-charcoal or other similar substance, non-attackable by acids, a plate of amalgamated zinc, and an exciting paste applied to the charcoal. This paste is composed as follows:—Chloro-mercurate of ammonium, $Hg.Cl^2.N\,H^4Cl$., 10 parts by weight, and chloride of sodium, Na. Cl., 3 parts. The charcoal plate, previously treated with paraffin, is covered with a cake of this paste, and on this cake is applied from five to ten thicknesses of Berzelius' Swedish filtering paper or asbestos soaked in a solution of chloride of zinc at 50deg. Beaumé, and chloride of sodium mixed in equal parts, which solution may also contain a little glycerine.

497. Improvements in Electro-magnets and Armatures, &c., *G. Little, Passaic, New Jersey, U.S.A.*—1*st February*, 1882. 6*d*.

The object of this invention is to obtain the maximum magnetic effect by having the metallic surfaces of the armature and magnets in contact, a rolling motion being given to the armature to avoid sticking between it and the poles. The figure shows how this is done. The magnet is composed of two heads upon a metal tube, with a helix wound between the heads, and each head is divided into poles of a double V-shape as shown in the figure. The armature B is cylindrical. The magnets are charged by the action of a circuit-closing device that admits the current to the helix. The poles are placed so as to operate progressively, that is, as the pole faces of magnet 1 are ceasing to act, the pole faces of magnet 2 come into action, and so on.

513. Improvements in Electric Meters, *C. V. Boys, Oakham.*—2*nd February*, 1882. 6*d*.

This relates to improvements on the inventor's patent No. 4,472, dated 13th October, 1881, for electric meters. According to the present invention a balance is kept oscillating by clockwork, the inventor employing as the spring of this balance a long strip of elastic metal, by which the balance is suspended, the torsion of this strip acting on the balance spring. This spring passes through a long slit in the arm of a lever, which has another arm at right angles to the former, connected to the armature of an electro-magnet in circuit. The armature is drawn in one direction by the attraction of the magnet, and in the opposite direction by an adjustable spring, in such a manner that the slotted arm of the lever takes a position embracing the torsion spring, determined by the current passing through the magnet. The velocity of oscillation of the balance is thus so proportioned to the current, that an index moved by the clockwork which is governed by the balance registers the amount of current passing through the coil in a given time.

538. Improvements in Electrical Accumulators, &c., *W. R. Lake, London.*—3*rd February*, 1882.—(*A communication from J. J. Barrier and F. Tourville de la Vernède, Paris.*)—6*d*.

The plates are formed of a lead ribbon, either smoothed, grooved, or perforated; this ribbon is wound upon itself either in circular, square, or other mode. The layers of the ribbon are separated by cement in which the ribbon is wound whilst in a semi-liquid paste. This paste is composed of one part platinised charcoal, one part litharge or very fine powder, and one part glycerine.

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SLIP

BRAZILIAN SUBMARINE TELEGRAPH COMPANY. — The traffic receipts of this company for the week ending November 24 amounted to £4,058.

ELECTRIC LIGHTING IN WINNIPEG.—Winnipeg, Manitoba, has now a tramway, and its main street, two miles long, has recently been lighted by electricity.

ELECTRIC LIGHTING AT CANTERBURY.—The Canterbury Poultry Show, to be held this month, will be lighted by the South Eastern Brush Electric Light Company.

ELECTRIC LIGHT IN NEW ORLEANS.—It is stated that the offices of the *Times Democrat* newspaper in New Orleans (U.S.A.) are to be lighted by the Levett-Müller system.

TO BE WOUND UP.—The Electric Works Company, of 3, Bucklersbury, E.C., is to be voluntarily wound up. Mr. W. F. Day, of 79, St. Mark's-square, West Hackney, has been appointed liquidator.

SOUTH AFRICAN TELEGRAPHS.—The revenue of Cape Colony derived from telegraphs during September last amounted to £4,715 17s. 1d., against £4,990 11s. 2d. in 1881, being a decrease of £274 14s. 1d.

SWAN LAMPS.—The Swan United Company are now manufacturing incandescent lamps of 50 and 100 candle-power. The 50 candle-power lamps require an E.M.F. of 50 volts, and the 100 candle-power 100 volts.

ELECTRIC LIGHTING IN AMERICA.—An American paper says:—"Grand Rapids, Mich., has three electric light companies in the field competing for its illumination. There are now 150 electric lamps used in the city."

SHIP STRUCK BY LIGHTNING.—During a severe thunderstorm a few days since the lightning struck the mizzenmast of the steamer "Prussian," at Govan, Glasgow, killing a man named Charles O'Niel, and injuring four others.

RESIGNATION.—Mr. José D. Husbands, of 31, Queen Victoria-street, C., has resigned his position as general manager of the London and Globe Telephone and Maintenance Company (Limited) in order to attend to his private business.

THE LANE-FOX LAMP.—We understand that the directors of the Anglo-American Brush Electric Light Corporation have placed the direction of the Lane-Fox incandescent lamp department, Portpool-lane, in the hands of Mr. St. George Lane-Fox.

THE GULCHER LIGHT.—It is stated that the Gülcher Electric Light and Power Company have orders for supplying electrical plant for lighting the Benares bridge, now being constructed on the Ganges by the Oude and Rohilkund Railway Company.

ELECTRIC LIGHTING AT BURY ST. EDMUNDS.—The Provincial Brush Electric Light Company have been instructed to light up the Corn Hall, Bury St. Edmunds, during the holding of the Blue Ribbon Mission there. The mission is to last for ten days from the 4th December.

THROWING STONES AT TELEGRAPH POSTS.—At the Dewsbury (Yorks.) West Riding Police Court the other day, four boys, residing at Liversedge, paid 10s. each and costs, with an alternative of one month's imprisonment, as the price of a few minutes' stone practice at telegraph poles.

ELECTRIC LIGHT AT SUNDERLAND.—According to a provincial contemporary, Lambton coal drops, near Sunderland, are to be lighted by eight Gülcher arc lamps and some Crookes incandescent lamps. These lights are designed to facilitate the loading of vessels by night and day.

ELECTRIC LIGHT IN LIMERICK.—Messrs. W. J. Shaw and Sons, of Limerick, are about to light up their offices and a portion of their factory with 60 Swan lamps. The current will be obtained from a Bürgin dynamo. The plant is to be supplied and erected by Mr. J. H. Greenhill, of Belfast.

ELECTRIC LIGHTING IN BELFAST.—Mr. J. H. Greenhill, of Belfast, has received an extensive order from Messrs. Harland and Wolff, ship builders of that town, for 11 more Crompton arc lights. They have had four arc lights running most satisfactorily for two months, hence this extension.

CABLE INTERRUPTED.—Information has been received of the interruption of the cable between Jamaica and Porto Rico, cutting off from telegraphic communication all the West India and Panama Company's stations in the West Indies except Jamaica. The company's ships have been ordered to repair the cable.

ELECTRIC LIGHT IN ABERDEEN.—The Brush Electric Light and Power Company of Scotland have contracted to light Castle-street, part of Union-street, Market-street, and Guild-street, Aberdeen, with the Brush arc lamps. Sixteen lamps will be used, which will be placed at a height of 20ft. above the ground.

GAS FIRED BY LIGHTNING.—During a thunderstorm on Friday week a curious occurrence took place at Bridge of Weir Station, Scotland. The lightning entered the signal cabin and ruptured a gas pipe, setting fire to the gas when liberated. The woodwork took fire, but the flames being observed were at once extinguished.

ELECTRIC LIGHTING IN MANCHESTER.—Messrs. G. and R. Dewhurst, one of the leading firms of Manchester, are lighting their warehouses with twelve Pilsen arc lights, 200 incandescent and some Joel semi-incandescent lamps. Messrs. Woodhouse and Rawson have been appointed by the Pilsen, Joel, and General Company, to carry out this work.

ELECTRIC LIGHTING ON THE TYNE.—The Wallsend Slipway Company have for some time past been using Brockie arc lamps to light up portions of their premises. They have within the last few days erected additional lamps of the same kind. The work has been carried out for them by Messrs. Jameson and Schaeffer, of Newcastle-on-Tyne.

ELECTRIC FIRE ALARMS.—The prospectus has been issued of the Electric Fire Alarm and Signals Company, with a capital of £100,000 in £1 shares. The company has been formed to purchase the patents of Sir E. B. Bright and the Exchange Telegraph Company. The temporary offices of the company are at 25, Cockspur-street, Charing-cross, S.W., Mr. R. S. Walker being secretary.

NEW COMPANIES.—The Manhattan District Telegraph Company of New York was incorporated on November 2 with a capital of 100,000dols. The line is to run from a main office in the vicinity of the Stock Exchange to other points in the city where branch offices may be established.—The Olmstead Electric Light and Power Company of New York was incorporated at Albany on November 6, with a capital of 1,000,000dols.

FACTORY BURNT DOWN.—The works of Messrs. Phillips Bros., the well-known makers of electrical apparatus, situated in Macintosh-lane, Homerton, were totally destroyed by fire

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on Sunday last. We are informed by Messrs. Phillips that, as they have another factory, the Lea Telegraph Works, Hackney Wick, which they started some time since, they hope in about a week's time to be in a position to execute all orders in the usual way.

Institution of Civil Engineers of Ireland.—At the opening meeting of this institution on Wednesday, the 6th December, a paper on "Magneto and Dynamo Electric Machines" will be read by Mr. J. Angelo Fahie, C.E., which will be illustrated by some experiments and numerous diagrams, while a number of incandescent electric lamps will be shown in action. We hope to give some extracts from this paper in a future issue.

Anglo-American Brush Electric Light Corporation.—The following is a copy of a resolution passed by the Board of the above company on the 29th November:—"Resolved, that a call of £3 per share be made on the £4 paid shares of the corporation, to meet the cost of extension of works and machinery and manufacture of stock, the same to be payable in instalments of £1 each on the 1st January, the 1st February, and the 1st March, 1883."

Private Bills.—The number of private Bills to be brought forward in the ensuing Session of Parliament is 253, a decrease of 70 as compared with last year. The total number of applications for Provisional Orders to be made to the Board of Trade is 212. This number exceeds the Provisional Orders applied for last year by 129. The increase is owing to the large number of Provisional Orders relating to the supply of electric light in London and the provinces, of which there are 141.

Underground Telegraphs in France.—The Paris correspondent of the *Standard*, telegraphing on Friday night, November 24, said:—"The inland telegraphic communication of France will, in time, be independent of wind and weather. On Wednesday next (November 29) a number of subterranean lines from Paris will be opened for service, and others will shortly follow. Fifteen millions of francs have already been expended on it, and it is contemplated to expend twelve millions more."

Electric Lighting in Liverpool.—Messrs. Lewis and Co., of Ranelagh-street, Liverpool, have arranged to light up their new premises and warehouses by means of the Pilsen system. They have appointed Messrs. Woodhouse and Rawson, of 11, Queen Victoria-street, E.C., contractors for the work. Fifty Pilsen arc lamps will be used, together with one large arc light of 4,000 candle-power nominal. This is one of the largest, if not the largest installation of arc lights for private purposes that we have heard of.

Professor Palmieri.—Very recently we announced, on the faith of a French contemporary, the death of Professor Palmieri, of the Vesuvius Observatory. Since then we have seen his death recorded in several papers. Within the last few days, however, it has been stated, on the authority of Messrs. Negretti and Zambra, that the professor is in his usual health, and that in all probability the report of his death originated in the fact that his nephew died recently We are very glad to record the fact that Professor Palmieri is still with us, and hope he may have many more years of activity before him.

Swan Lamps and the Russian Government.—We have the best authority for stating that the following paragraph, published a day or two since in the *Daily Telegraph* money article, has no foundation in fact. The paragraph is as follows:—"It is stated that the Swan United Electric Light Company have sold to the Russian Government for £100,000 in cash the exclusive right to use their invention throughout the empire, and to sell their lamps. There can be little doubt that the employment of the electric light in the larger cities and towns of Russia could be made a most lucrative State monopoly. The company's paid-up capital is £160,000, in 80,000 shares, the quotation of which to-day was $2\frac{1}{8}$, $\frac{3}{8}$."

Electric Lighting at Birmingham.—Messrs. R. W. Winfield and Co., of Cambridge-street Works, Birmingham, gave an exhibition of electric lighting early this week in one of their show rooms. The room in question had been arranged as a drawing room, and was lighted by means of a Crompton arc lamp, placed in a large opal glass bowl, supported on a pedestal in the middle of the room, the light from which was reflected on the ceiling, and so diffused throughout the room. The remainder of the works were also lighted by means of Crompton arc and Swan incandescent lamps, the current being generated by Bürgin machines. Mining lamps, table lamps, and brackets and fittings of all kinds, manufactured by Messrs. Winfield, were also shown.

Charing Cross Electric Railway.—Notice has been given of intention to apply for a Bill in the ensuing Session empowering the construction of a railway from Cockspur-street, Charing Cross, near King Charles's statue, and joining the railway authorised by the "Charing Cross and Waterloo Electric Railway Act, 1882;" also another railway forming a junction with the above electric railway, near Belvedere-crescent, and terminating in the parish of Christchurch, Southwark, S.E., near the Blackfriars-road; also other railways in continuation of the above, which will finally terminate close to the Royal Exchange in Cornhill, E.C. The Bill will also authorise the London and South Western Railway Company to contribute towards the cost of constructing the above intended railways.

Electric Light at Birmingham.—The stand of Messrs. Tangye at the Birmingham Cattle and Poultry Show, which was held from the 25th to the 30th November, in Bingley Hall, was lighted by means of Edison lamps, some sixty or seventy of which were used. Two Edison dynamos, one sixty-light, and another fifteen-light, were driven by means of Messrs. Tangye's coupled gas engines of $2\frac{1}{2}$ horse-power. In these engines there are two impulses at each revolution, and consequently steady working is obtained, this being, as everybody knows, of the utmost necessity in incandescent lighting. The lights were erected by Messrs. Smith and Chamberlain, of the Solar Works, Birmingham, who had obtained special permission from the Town Council to do so. This is, we believe, the first time that the Edison light has been shown in Birmingham.

Electric Lighting in London.—The St. Olave's Board of Works will hold a special meeting on the 19th January next to consider the expediency of applying for a license from the Board of Trade to supply electricity. The Board are evidently in no great hurry.—The Lewisham Board of Works, after hearing the report of their delegate to the recent conference of vestries, &c., which was to the effect that local authorities had better apply for licenses, instructed their clerk to "look into the Act."—The General Purposes Committee of the Hackney Board of Works recommend the Board to oppose other companies, but are averse to a provisional order being obtained.—The St. James's (Westminster) Vestry have resolved to apply for a license.—The Bermondsey Vestry have fixed the first Monday in January for the consideration of the question of obtaining a license.

The Telephone on Railways.—The Lancashire and

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Yorkshire Railway Company are introducing a system of telephonic communication connecting the principal signal boxes been Mirfield and Low Moor, which, when completed, will afford an addition to the block system, &c., for the working of the traffic along the Spen Valley. The instruments are being put in by Messrs. D. Mosley and Sons, of Manchester. This, or a similar means of communication, has been extensively adopted by the company in the Yorkshire district, and has been found to answer the purposes for which it was intended admirably. Some time ago the ordinary telegraphic service, which had been in use on the Cleckheaton branch some time, was removed, and the company recently proposed to again bring it into operation, but after further consideration they decided to introduce the improved means now adopted. Railway companies generally would do well to follow this good example.

Electric Light in Port Elizabeth (South Africa).—A colonial paper of the 18th October says:—"Last Monday night the electric light was exhibited for the first time in Port Elizabeth by the South African 'Brush' Electric Light and Power Company, and we may well congratulate the company, and their efficient electrician on the perfect success of the experiment. Six lamps were lighted—three in Market-square and three on the Hill, near the Port Elizabeth Club—at half-past eight o'clock, and were kept lighted till twelve o'clock. A large concourse of people gathered together at both places to see the novelty, and all were much pleased with the brilliancy of the lights and the steadiness with which they burnt." The lights were to be exhibited for one month. The dynamo was driven by a seven horse-power engine by Hornsby and Sons, of Grantham, Lincolnshire. The lamps, &c., were erected under the superintendence of the company's electrician, Mr. R. L. Cousens.

E.M.F. of a Zinc-Carbon Cell.—According to M. Berthelot, the E.M.F. of a zinc-carbon couple in dilute sulphuric acid is subject to great variations owing to polarisation. When the circuit is first closed, the E.M.F. is greater than that of a Daniell cell in the ratio of 1 to 1·29, but if the circuit be kept closed it rapidly decreases, and at the end of 36 hours is less than half that of a Daniell cell. On interrupting the current the E.M.F. gradually increases, but never regains its primary intensity. If, however, the carbons and porous cells are disconnected, washed with water, and again set in place, then, on closing the circuit, the E.M.F. obtained at first is the same as before. One of these couples, when the circuit is first completed, will not decompose acidulated water, but if a zinc-cadmium couple is added decomposition takes place. Two zinc-carbon couples will decompose potassium sulphate until polarisation has lowered the E.M.F. below that of two Daniell cells.

A Peripatetic Paragraph.—Some time ago (*vide Electrician*, Vol. VI., p. 216, March 19, 1881) we published an illustration, with short description, of the longest span of wire in the world, viz., that over the River Kistnah, between Bezorah and Sectanagrum, in India, which is more than 6,000ft. across. Our information and illustration were derived from private sources. Since that time we have come across our illustration and letterpress in various shapes and guises; sometimes the letterpress without the illustration, sometimes both together, but never with the source acknowledged. The whole is now reduced to a convenient little paragraph, which has helped several printers and sub-editors to fill up a column. Thus we have seen it in the *Journal* of the Franklin Institute, *Scientific American* (more than once), *Operator*, *Journal of the Telegraph*, *La Lumière Electrique*, *L'Electricité*, *L'Electricien*, *Engineer*, several provincial papers, &c. After this list we think we are justified in the use of the word "peripatetic."

Long Distance Telephoning.—A novel experiment is now in progress with a view to overcoming the difficulties attendant upon long-distance talking. 'Between Boston and Worcester (U.S.A.) a line is being constructed of No. 4 gauge wire, which reduces the telephone distance between the two cities about one-half. This line, says the *Scientific American*, will cost 10,000 dollars, whereas an ordinary line of No. 9 wire would cost only about 4,000 dollars. If the experiment is a success, the line will be extended to Springfield, and similar lines will be built from Boston to Portland, Plymouth, N.H., and other distant points, enabling subscribers there to talk with Boston as readily as subscribers in Lowell, Salem, Lawrence, and other neighbouring places. The ordinary telephone line, running straight across the country, costs from 100 dollars to 150 dollars per mile. The big wire is now completed between Boston and Hopkinton, a distance of twenty miles. Communication over the line on this twenty-mile stretch is as distinct as in the city.

The Telegraph Construction and Maintenance Company.—Notification is given that application will be made next Session on behalf of the Telegraph Construction and Maintenance Company for an Act for the removal of doubts as to the meaning of the company's Memorandum of Association, dated April 6, 1864, to extend the objects for which the company was established, and to include amongst those objects the construction, laying down, maintenance, purchasing, hiring, letting, selling, working, and use of works and apparatus for the production and use of electric and magnetic or any other force for any purpose whatsoever; and the purchase, importation, manufacture, and sale of all materials, articles, and things in any way used or connected with the production, transmission, and use of electric and magnetic or any other force. Authority will also be asked in the Act to confer upon the company all such powers, rights, and privileges as may be necessary or expedient for effecting these objects, and to vary and extinguish all rights and privileges which would in any way interfere with the objects of the Bill, and to confer other rights and privileges.

The Lighting of the Law Courts.—The daily papers have told us that the ceremony of opening the law courts is to take place on Monday next. It is not, perhaps, so generally known that great efforts are being made to have all the arrangements connected with the experimental electric lighting ready for that day. Such, however, is the case, and we have been astonished at the rapidity with which the work is being carried on. Messrs. R. E. Crompton and Co. have the work in hand, and by the time these lines are read, the engine, a 20 horse-power compound, by Marshall and Sons the counter-shafting, the dynamos, and the wires will be mostly in their places. Three courts are to be lighted by Swan lamps. The fittings have been specially designed for each court. They have been constructed by Messrs. Winfield and Co., of Birmingham. Besides the three courts, some of the corridors will be lighted by similar lamps. Altogether about 150 incandescent lamps will be used, and six arc lamps. The arc lamps are, we believe, of a new pattern. It is said that a trial will be made of the FitzGerald-Crompton secondary battery at this installation. Next week we shall be able to describe the whole of the arrangements. Meanwhile, so far as we can judge, the work is being carried out in a very able manner, and we have no doubt the result will be satisfactory.

Electric Lighting in the Country.—The Canterbury Town Council have resolved to apply to the South Eastern

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Brush Electric Light Company and other companies with the object of ascertaining upon what conditions they would act with the Town Council in the event of the latter obtaining a license to supply the electric light. The West Hartlepool Improvement Commissioners think that, as no independent company has yet given evidence of their intention to apply for an order to supply electricity in that town, that they, the Commissioners, had better "bide a wee," at all events for the present. The Stockton Town Council, being in the same case, are of the same opinion. The Luton (Bedfordshire) Town Council have resolved not to apply for an order at present, but will send a deputation to Mr. Chamberlain, "asking (*inter alia*) that, if possible, no order should be granted for twelve months, that the term of any order or license granted to a company should not exceed twelve or fourteen years, and that a clause should be inserted empowering the council to purchase the plant and property of the company at the end of such term, without any payment for goodwill." The Pemberton (Lancashire) Local Board will not apply for an order. The Stourbridge (Worcestershire) Improvement Commissioners will oppose outside companies. The Salford Town Council, "in the present uncertain state of electric lighting," will not apply for an order, but the Newcastle-on-Tyne Town Council are of a different opinion, and will obtain an order.

Incandescent Lamps and Photography.—According to Mr. T. Bolas, a 5-candle Swan incandescent lamp can be maintained at any required temperature, from a low red heat up to the volatilisation point, by slightly modifying an ordinary Gramme machine, thus affording a ready means of obtaining sufficient light to take a photograph in from two to three seconds. To obtain this result, a small electro-magnet is arranged as a keeper over the jaw pieces surrounding the revolving armature in a Gramme machine, so as to form consequent poles with those of the field magnet, the circuit being completed through the subsidiary electro-magnet and the incandescent lamp. The subsidiary electro-magnet placed in this position gives the machine a character intermediate between a magneto and a dynamo machine. When the armature is caused to rotate, and the external circuit is left open, a considerable difference of potential arises between the poles, although not so great as it would have been if the soft iron core of the electro-magnet were not there acting as a keeper to the field magnet. This potential is sufficient to insure the efficient action of the machine even when a very high resistance is included in the external circuit. When a 5-candle Swan lamp is placed in circuit, and the machine is turned with one hand at full speed, the lamp is almost immediately destroyed; but by regulating the speed any required temperature may be maintained, from a low red-heat upwards, a light of from 200 to 300 candles being readily attained. Of course, the lamp is soon destroyed, but as it is used only for a few seconds each time, from fifteen to twenty portraits can be taken before that occurs.

Provisional Orders.—The following additional notices of intention to apply for provisional orders empowering the supply of electricity for lighting and other purposes have been made public:—The Metropolitan Brush Electric Light and Power Company have given such notices with reference to the following London districts, viz.: Strand, Camberwell and Penge, St. George's (Hanover-square), St. James's (Westminster) and St. Anne's (Soho), Kensington and St. Margaret's (Westminster), St. George's-in-the-East, Mile End Old Town, Whitechapel, Limehouse and Poplar, Lambeth, St. Giles and St. George's (Bloomsbury), Holborn, Chelsea, St. Martin's-in-the-Fields, and Westminster, St. Marylebone, and Paddington. The Provincial Brush Electric Light and Power Company have also given a similar notice with regard to Sudbury. The Union Electric Light and Power Company of St. Stephen's-chambers, Telegraph-street, E.C. (an offshoot of the Pilsen, Joel, and General Company) will endeavour to obtain powers for Southampton, Plymouth, Devonport and East Stonehouse, Bradford (Yorkshire), Rochdale, Chester, and Exeter. Messrs. Ferranti, Thomson, and Ince, 3, Fenchurch-avenue, E.C., have given notice as regards Chelsea and Hampstead, in London. The following Corporations notify their intention to supply their own districts if they can obtain orders, viz.: Darlington, Blackburn, Scarborough, Beccles (Suffolk), Rochdale, Grantham (Lincolnshire), Over Darwen (Lancashire), Winchester, Leicester, South Shields (Durham), Carlisle, and Halifax. The following local authorities will do likewise, viz.: Malvern (Worcestershire), Folkestone (Kent), Pudsey (Yorkshire), and Wallasey (Cheshire).

Electrolysis of Hydrogen Peroxide.—A dilute solution (three grains per litre) of hydrogen peroxide undergoes electrolysis in two different ways. With sufficiently high electromotive force, oxygen and hydrogen are given off at the two electrodes, but with low electromotive force, such as that of a zinc-cadmium couple, only oxygen is given off, and no hydrogen is evolved at the negative electrode. Under these circumstances electrolysis resembles the spontaneous decomposition of the peroxide, but is accelerated by the action of the current. Either the hydrogen peroxide splits up into oxygen and water, or, more probably, a secondary reaction takes place, and the electrolysed hydrogen combines with undecomposed hydrogen peroxide, forming two molecules of water, thus, $H_2 + H_2O_2 = 2\,H_2O$. The final result, $2\,H_2O_2 = 2\,H_2O + O_2$, is exothermic, and develops + 43·6 cals., for $H_2O_2 = H_2 + O_2$ absorbs − 47·4 cals., and $H_2 + H_2O_2 = 2\,H_2O$ develops + 90·6 cals. This form of electrolysis can consequently be effected by any electromotive force, however feeble. When the electromotive force is equal to that of a Daniell cell, hydrogen is given off as well as oxygen, and the simultaneous evolution increases as the electromotive force increases. The electromotive force of a Daniell cell is the result of a reaction which develops + 49 cals., a quantity slightly higher than that absorbed by the decomposition of the hydrogen peroxide into its elements. The peroxide may possibly first split up into oxygen and water, the latter then undergoing electrolysis, but in this, as in all cases of electrolysis, only the initial and final conditions enter in the calculation of the minimum electromotive force required. For the same reason the presence of dilute acid does not interfere with the result. That both modes of electrolysis may take place simultaneously, as the author has already found in the case of ferrous and manganous sulphates (*Comptes Rendus*, 93, 760) is shown by the variations in the relative proportions of the oxygen and hydrogen evolved. With higher electromotive force sufficient to decompose water the decomposition becomes complex, and the ratio of hydrogen to oxygen evolved is increased in consequence of the electrolysis of the water present.—Abstract of Paper by M. Berthelot in *Comptes Rendus*, 95, 8—11, published in Chemical Society's *Journal* for November.

The Danger of Overhead Telegraph Wires.—On Wednesday afternoon a deputation from the Westminster District Board of Works waited in the Conference Room, House of Commons, on the members for Westminster, Mr. W. H. Smith and Lord Algernon Percy, with respect to the danger to life created by the increased number of telegraph

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and telephone wires which were being stretched across the thoroughfares.—Mr. Reynolds Yorke, M.P., having introduced the deputation, Mr. Horn said they wished to point out the great danger arising from the increased number of telegraph and telephone wires in their district. While the Government had done their best to remove these wires, which were dangerous to the public and detrimental to the beauty of their city, many companies had sprung up and were straining wires across the thoroughfares. It had been stated that the Board were liable for any damages caused by this, but they had no control in the matter.—Mr. W. H. Smith said he thought that, as a nuisance authority, the Board might give notice to the companies to remove the wires as being dangerous to the public safety.—Mr. Harris, clerk to the Board, thought they might, for the straining of a wire from one point to another across the street was very different from the erection of a post on a house.—Mr. W. H. Smith said that last session the Attorney-General said the local authorities had the power, and were responsible.—Mr. Horn: They are responsible, without having the power.—Lord A. Percy said the Postmaster-General stated that only nineteen miles of wires had been put up within the past year, and the tone of his answer to a question was that the Government had no power to stop the erection of further wires.—Mr. W. H. Smith thought the question was whether the Board had the power to interfere with the wires. They could prevent a pipe or a bridge being put across the street, and this was a pretty similar case.—Mr. White said the matter was urgent, as the board would be held responsible for loss of life.—Mr. W. H. Smith: Then you must have power to prevent it.—Mr. Yorke, M.P., suggested that the Local Government Board should be asked if such power existed in the local board.—Mr. W. H. Smith advised the deputation to act on his hon. friend's suggestion. If the answer of the Local Government Board was in the negative, then he should concert with his colleague (Lord Percy) what measure was best to be taken.

Measuring Changes of Temperature by Thermo-Electricity.—The following account of the arrangements and apparatus used in some experiments made by Professors Marshall and Smith and Mr. Omond to determine the lowering of the maximum density point of water by pressure is taken from the *Proceedings* of the Royal Society of Edinburgh, Session 1881-82, No. III:—"The changes of temperature which followed changes of pressure were measured by thermo-electricity. One junction of a thermo-electric circuit of very fine copper and iron wire was placed inside the gun (a strong iron vessel used in connection with a powerful force pump for producing the compression), the wires passing out between two discs of leather well soaked in oil near the bottom, which could be taken off. The others were soldered to thick copper wires in connection with a dead-beat reflecting galvanometer, and placed in a vessel of water, which was kept at as uniform a temperature as possible, one of them being put into a test tube to prevent the slight voltaic action which disturbed us in our earliest experiments. As we had in some of our experiments to measure extremely small changes of temperature, the galvanometer was made very sensitive by the controlling magnets, and the deflections read on a scale about $2\frac{1}{2}$ metres from the galvanometer. We were enabled in this way to measure as small a change of temperature as $\frac{1}{300}$° C, even with a single thermo-electric pair. However, any change in the electric field was at once felt. The rooms we worked in were on the ground flat, looking into Chambers-street, and every passing vehicle, on account of its iron fittings, disturbed us. The reader of the galvanometer scale, who was in a darkened room by himself, could generally tell the direction in which a vehicle was moving from the motion of the image on the scale, and on once crying out that a man walking past affected the galvanometer, the experimeter at the pump immediately rejoined that he was carrying some iron on his back. To avoid this change of the magnetic field, we took one set of observations at midnight. As it was generally impossible to determine directly with a thermometer the temperature of the junction inside the gun, to enable us to interpret the galvanometer readings, there was an extra thermo-electric circuit, as nearly as possible the same as that connected with the gun, whose junctions were in vessels of water, so that the temperatures could be directly read with a thermometer, and altered at pleasure. Any change in the sensitiveness of the galvanometer was each day detected by this arrangement."

The Dangers of Electric Lighting.—In the Mill mutual insurance companies in New England there were sixty-one establishments lighted by electricity up to last May. With few exceptions the lights had not been in use previous to the fall of 1881, and many had been started early in the spring. In these sixty-one establishments Mr. C. J. H. Woodbury records twenty-two fires due to electric lighting, and assignable to the following causes: Eight were from globules of melted copper or particles of hot carbon falling out from the bottom of the globes. The actual number of fires from this cause was probably many times this number. This class of fires will not continue to happen, as all makers now set their lamp globes in a tight stand with a ridge around the edge. A flat plate will not answer the purpose, as there was one instance where drops of melted copper rolled off and started a fire. Four fires were due to leaking water or washing floors, and two more were caused by water in a dye-house condensing on the building to which uninsulated wires were fastened. In most of these instances a grounded circuit formed one of the two connections necessary to divert the electricity from the wires. Many of the lower carbons fell from lamps, and five fires were caused where they fell upon combustible material. Three fires were caused by cross-arcs from one wire to another, where uninsulated wires were fastened against conductors. In one instance the conductor was formed by dust settling upon uninsulated wires, and on a damp day it absorbed enough moisture to form a path for the formation of a cross-arc, which started a slight fire. In another instance the wires were fastened to a damp beam, which was decayed, and was burned nearly in two by the smouldering fire. And in a third instance damp brickwork in a tunnel was a sufficient conductor to establish an arc, which did not do any material damage there, but injured the dynamo. Two fires were caused by improper switches; two by water reaching the wires of a circuit already grounded; and one from wires coming in contact with a building, so that their insulation was worn away. Electricity forms the safest method of illumination when the following precautions are observed:—The system insulated throughout, so that there is no electrical communication with the earth, or from one part of the apparatus to another, except through the proper conductors, even if the wires should be exposed to water; all switches made with lapping connection, so that no arc can be formed; arc lamps provided with globes closed underneath, and the frame so arranged that the lower carbon could not fall out, even if the clamp failed to hold it securely; the wires of incandescent systems provided with a sufficient number of fusible links to secure the system against any damage from an excess of current.

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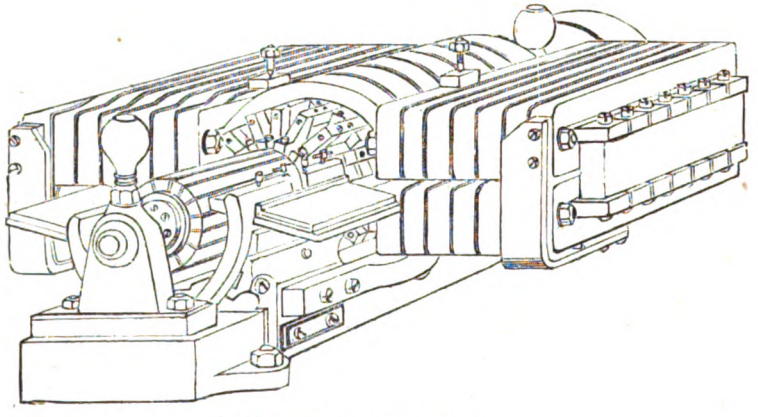
THE MUNICH EXHIBITION.—IV.

Our last paper concluded with a description of the modification in the Crompton arc lamp as exhibited at Munich. We stated that one Bürgin dynamo was used to supply the current for Maxim or Swan lamps. The Maxim lamp was that of the ordinary type, while the Swan was a new 40-candle lamp not, so far as we know, previously exhibited. For many months we have been experimenting with Maxim and Swan lamps, and often have brilliantly lighted the room in which we are now writing with one Maxim lamp. The room is similar to those in numbers of suburban houses, about the dimensions 16ft. by 12ft. by 9ft—that is about 1,700 cubic feet. We run the Maxim lamp at about 50 candles, and think at that power they will be found economical. Experimental work is, as a rule, not good for length of life, but so far the Maxims have a length of life equal to that of any other lamp. The Maxim lamps at Munich were used to illumine a room filled with antique furniture. The Swan lamps, as we have said, were of a new type, to give a normal candle-power of 40 candles. The resistance of these lamps is about 70 ohms hot, and they require an E.M.F. of about 90 volts, thus getting a current through the carbons, $C = \frac{E}{R} = \frac{90}{70} = 1{\cdot}3$ ampere nearly. The horse-power absorbed by each lamp is known from the equation $\frac{C \cdot E}{746}$, which in this case gives

$$\frac{1{\cdot}3 \times 90}{746} = \frac{117}{746},$$

so that from 6 to 7 such lamps may be expected to be obtained by the expenditure of one horse-power in the carbons—say six, and this gives about 240 candles per horse-power, a good result. The arrangements regarding the exhibits of Messrs. Crompton and Co. were carried out by Mr. Bollinger, of Milan, the agent of this firm. Our thanks, and those of many another visitor, are due to Mr. Bollinger for his assistance in pointing out all that was worth seeing at the Munich Exhibition.



Siemens' Depositing Dynamo.

The great firm of Siemens and Halske did not exhibit directly at Munich, but one of their agents, M. Riedinger, exhibited machines and lamps of the ordinary construction.

Some latitude being allowable in a report, a brief reference to a machine exhibited at Paris, but, so far as we know, not yet illustrated in an English paper, may be permitted here. This machine is of the type used for depositing metals, and is therefore made to give quantity and not intensity. It will be seen from the figure that the coils of the field magnets are really discs of copper an inch or so in thickness, similarly the armature coils are really bars of copper. Machines of this type are employed at the works at Öker, as we have said, to deposit copper. We remember that slabs of the deposited copper were exhibited at Paris, and had hoped to have seen similar exhibits at Munich. The machines of the Siemens make exhibited at Munich were the ordinary direct and alternate current machines, well known and extensively used both with arc and incandescent lamps. There are many people who maintain that the length of life of an incandescent lamp is increased by using an alternate current machine, and Siemens machines of this type are frequently used with Swan lamps.

An interesting exhibit was that of M. L. Weiller, whose representatives in Great Britain are the Phosphor-Bronze Co. The wires exhibited were some of phosphor-bronze, which is a new alloy that is said to give exceedingly favourable results. These wires were referred to by Mr. Preece in his address to the Society of Telegraph Engineers, and the following tables, showing their properties, have been published by our contemporary *Engineering*. These tables will save us from any further remarks, as they tell the whole value of the wire:—

I.—*Table showing Properties of Silicious Bronze Wires.*

Nature of Wire.	Diameter.		Electrical Resistance per Kilometre.	Resistance Kilogs.	Conductibility Compared with Copper.	Resistance to Rupture. Tons per Square inch.
	mm.	in.	ohms.			
Copper	1	.04	20.36	21.8	100	12.3
Telephone phosphor-bronze wire	1	.04	70	70	29.3	56.3
Telephone silicious bronze wire	1.08	.042	48	80	36	56.3
Telegraph silicious bronze wire	1.30	.051	12.13	67	97	32.1
Silicious bronze wire covered with magnetic oxide for telegraph lines, in the vicinity of the sea, and at railway stations	1.50	.06	9.7	91	93	33
Telegraph silicious bronze wire	1.70	.067	8.6	137	82	38
Telegraph silicious bronze wire	1.94	.076	5.8	140	93	33

If we take as a type of telephone conductor the wire 1 mm. in diameter, and as a type of telegraph line the wire 2 mm. in diameter, the comparison with wires in ordinary use will be as in the following Table:

II.—*Comparison of Phosphor and Silicious Bronze with Iron and Copper Wires.*

Nature of Wire.	Resistance to Rupture.	Electrical Resistance per Kilo.	Conductibility Compared with Copper =100.	Resistance to Rupture.
I. *Telephone Wires* 1 *mm. dia.:*	kilo.	ohms.		tons per sq. in.
Silicious bronze, Weiller	70	56	36	56.3
Phosphor-bronze, Weiller	70	70	29.3	56.3
Phosphor-bronze, Montefiore	59	107	19	48
Swedish Iron	28	135	15.8	22.7
Siemens-Martin steel	32	166.8	13.3	26.5
Pure copper	21.8	20.57	100	12.3
II. *Telegraph Wires* 2 *mm. dia.:*				
Silicious bronze, Weiller	157	5.1	97	33
Phosphor-bronze, Weiller	138	6.4	76	27.9
Swedish iron	113	33.8	15.8	22.7
Siemens steel	132	41.7	13.3	26.5
Pure copper	87	5	100	12.3

III.—*Weight of Different Telegraph Wires of Equal Conductivity.*

—	Diameter.	Resistance.	Weight per Mile.
	mm.	ohms.	lb.
Silicious bronze	2	5.1	88.5
Phosphor-bronze	2.13	5.1	110.8
Swedish iron	5.10	5.1	584
Siemens steel	5.70	5.1	931

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CONNECTED GENERAL THEOREMS IN ELECTRICITY AND MAGNETISM.

BY OLIVER HEAVISIDE.

In mathematical investigations relating to electro-magnetism, it often happens that the equations assume such a very complex form that the real meaning of the relations expressed by them becomes hidden away, as it were, beneath a tangled mass of x, y, z's, and can only be recognised by groping about from one equation to another, comparing them, selecting certain equations as important, rejecting others as needless, and, finally, from the few selected main equations, serving as successive stepping-stones, determining the essential nature of the relations under investigation. That there are so many quantities involved in electro-magnetism is one reason for this complexity and obscurity, but it is immensely increased by the circumstance that they are usually vectors, or directed quantities, requiring three specifications, instead of the one which is sufficient for a scalar quantity; and from the ordinary $x\,y\,z$ system only recognising magnitudes, so that a set of three equations is required to fully exhibit a single relation between a pair of vectors. Thus we may say, in words, that the current is the curl of the magnetic force, but if we have to express this symbolically we require three equations, which express the same thing for the components in three rectangular directions.

A very remarkable system of mathematics was invented by Sir W. Hamilton, called quaternions, which may be described as the calculus of vectors. Owing to the universal presence of vectors in physical science, it is exactly fitted to express physical relations. Instead of breaking up vectors into three components, working upon them as scalars, and then, when required, compounding them again to get back to vectors (a most roundabout method) in the calculus of vectors we may fix our attention upon the vectors themselves, and work upon them direct. One equation takes the place of three. Investigations are greatly shortened. The real relations between the quantities are not lost sight of, and this again serves to annihilate a lot of useless work that might be done in the scalar system owing to obscurity.

The calculus of quaternions ought then, one would say, to speedily supplant the ordinary methods in physical applications; in fact, it should have done so already. But it has not. Does this arise from mere Conservatism—the hatred of having to leave the old ways, even for better? Although this may be partly true, it cannot be the whole truth. Against the above stated great advantages of quaternions has to be set the fact that the operations met with are much more difficult than the corresponding ones in the ordinary system, so that the saving of labour is, in a great measure, imaginary. There is much more thinking to be done, for the mind has to do what in scalar algebra is done almost mechanically. At the same time, when working vectors by the scalar system, there is great advantage to be found in continually bearing in mind the fundamental ideas of the vector system. Make a compromise; look behind the easily-managed but complex scalar equations, and see the single vector one behind them, expressing the real thing.

An easily-grasped example of the importance of considering the vector itself may be here given. In a field of electric force, what relation does the total amount of force passing outward through a completely closed surface bear to the amount of free electricitiy enclosed by it? Consider a single charge e within the surface. By definition, the electric force is radial, of strength $e \div r^2$ at distance r; and since $4\pi r^2$ is the area of the spherical surface of radius r, the total force through it is $(e \div r^2) \times 4\pi r^2 = 4\pi e$. This is perfectly clear when the closed surface is that of a sphere, and the charge is at its centre. But put the charge at some other part of the enclosed space. The force is now of different strength at different parts of the surface; and, moreover, it does not go straight through, perpendicular to it, and it is quite a complex matter to sum up the total force by algebraical methods. But if we fix our attention upon the system of force, which we may do by imagining a set of equally-distributed radial lines drawn from the charge, inseparably connected with it, we see at once that the same amount of force as before, viz., $4\pi e$, goes through the spherical surface at whatever part of the enclosed space the charge may be placed, just as the same amount of light would come from a candle substituted for the charge; and, moreover, that the same is exactly true for any other closed surface, however complex its form may be, and however many times a radius drawn from the charge cuts the surface before finally emerging never to enter again. The only essential thing is that the surface must *enclose* the charge. Now this being true for one charge, is true for any number, so that the total amount of force passing out through a closed surface is always $4\pi \times$ total charge within, however it may be distributed.

[If the surface be unclosed, we may, in the case of a single charge, substitute for it a portion of a spherical surface bounded by the same lines of force, whence it follows that the amount of force passing through the unclosed surface is $4\pi e \times$ ratio of area of the portion of spherical surface to the whole, *i.e.*, $e \times$ solid angle subtended at e by the line bounding the unclosed surface, by the definition of a solid angle.]

An immediate consequence is that the electric force at the surface of a charged conductor is $4\pi\sigma$, where σ is the surface density. For, by the foregoing, $4\pi\sigma$ is the amount of force coming from unit of area of the surface. Now there is no force within the surface, otherwise there could not be equilibrium, therefore $4\pi\sigma$ is the external force; it is perpendicular to the surface, because if it were not, there would be force along the surface, which is against equilibrium again.

Besides the complexity above referred to, there is in general working a frequent repetition of the same succession of operations in different places. These operations may themselves be of a complex nature; yet, if they are carried out in one investigation, the results may be transferred to another, perhaps relating to a quite different matter. Hence the utility of general theorems. The three allied theorems which we will now discuss are of great assistance in electricity and magnetism. Analytical proofs of them may be, and are given, which are only to be followed with some difficulty, especially as regards No. II. below; one I have seen in a German work of No. I., which is comparatively simple, was about six pages long. This is by no means necessary, for without losing the character of exactness, the demonstrations may be given in words, although in the final expression of the theorems symbols are desirable.

I. The first theorem relates to the surface-integral of a vector over a closed surface, and we require to substitute for it a volume-integral taken throughout the enclosed space. We have already had one example of this, *viz.*, for electric force; the quantity integrated throughout the space being $4\pi\rho$, where ρ is the volume-density of electricity. We now require it in a more general form, applicable to any vector. But, to fix ideas, we may conveniently think of electric force. What we really require is the excess of the amount of force leaving the surface at some places over that entering it at other places. We may go all over the surface, dividing it into little bits, find the flow through each little bit, and add the results together. If R is the force, dS an element of surface, ϵ the angle between R and the normal outwards, the force through dS is R$\cos\epsilon\, d$S, and the surface-integral is $\iint \mathrm{R}\cos\epsilon\, d\mathrm{S}$ over the whole surface. We now require to express this in the form of a volume-integral taken throughout the enclosed space. In the first place, we may easily prove that this is capable of being done. For divide the volume V into two parts, V_1 and V_2. The act of division creates a fresh surface, or, rather, a pair of twin surfaces, born at identically the same moment, like + and − electricity. Now consider the integrals over the two complete surfaces of V_1 and V_2. The surface-integral over V_1 consists of the integral over that portion of the surface of V which the piece V_1 possesses, and of the integral over the new surface, one of the twins. Similarly, the integral over surface of V_2 consists of the integral over the other portion of the surface of V, and of the integral for the other twin. Now regard only the twin surfaces. Put the surfaces together, so as to get the original volume; the two integrals are exactly equal, for the surfaces coincide, and they

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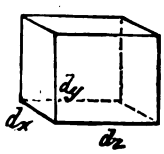
are reckoned in opposite directions; therefore, by addition, they cancel. [The case of discontinuity in the force within the volume V is here excepted.] Therefore, the integral over the closed surface of V equals the sum of the two surface-integrals over the complete surfaces of the two pieces V_1 and V_2 into which we divided V. The same thing is obviously true if we divide each of our two volumes into two more; the original integral now equals the sum of the four complete surface-integrals, the newly created twin integrals always cancelling when taken together. And since this may be carried on to any extent, we may divide the volume V into an indefinitely great number of elements, each $= d\,V$, and our surface-integral is exactly equal to the sum of all the surface-integrals outwards over the complete surfaces of all the elementary volumes. Thus the volume-integral is possible; and further, we know what the element of the volume-integral is. It is the integral of force outward over the surface of the element of volume.

It now only remains to put this element of the volume-integral into a symbolical form in terms of the force. Let the element of volume be a cube, edges dx, dy, and dz. Let X, Y, Z be the components of R at the corner where dx, dy, and dz meet. The amount of force leaving the cube is the sum of the six amounts leaving it through the six plane faces; each of these is force × surface, therefore they are



$$-X\,dy\,dz \text{ and } \left(X + \frac{dX}{dx}\,dx\right) dy\,dz;$$

$$-Y\,dz\,dx \text{ and } \left(Y + \frac{dY}{dy}\,dy\right) dz\,dx;$$

$$-Z\,dx\,dy \text{ and } \left(Z + \frac{dZ}{dz}\,dz\right) dx\,dy;$$

Adding these together, we get

$$\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right) d\,V,$$

where $d\,V = dx\,dy\,dz$, the element of volume. This is the element of the volume-integral; consequently we have

$$\iint R\cos\epsilon\,dS = \iiint\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right) d\,V \quad . \quad . \quad . \quad (I.)$$

for the complete expression of the theorem. The left side is the integral of R over the surface of V; the right side is the equivalent volume-integral, to be extended throughout V.

Although we have spoken of force, it is true for any vector. If R is the velocity of an incompressible fluid at any point, and X, Y, Z its components, then, since the same quantity of fluid must enter as leaves any closed surface, the surface-integral is *nil*, and

$$\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = 0$$

is true everywhere. This is the equation of continuity. If R is current density, the same equation is true. If R is electric force, the same equation applies wherever there is no free electricity.

Where there is free electricity, let ρ be the volume-density, then $\rho\,d\,V$ is the amount within the element of volume $d\,V$. We know that 4π times this is the surface-integral of force over the element. Consequently,

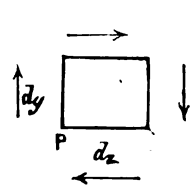
$$4\pi\rho\,d\,V = \left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right) d\,V,$$

or

$$4\pi\rho = \frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz};$$

which is the general relation between electric force and electrification. Now, when ρ is −, lines of force converge to the element, whence $-\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right)$ is called the "convergence" of the vector R. Electric force has no convergence save where there is free electricity; on the other hand, electric currents have no convergence *anywhere*, neither has their magnetic force, nor their vector-potential, nor any of the quantities considered in Article II. on "Magnetic Force and Current."

II. We now come to unclosed surfaces, or surfaces bounded by a closed curve. If we take any closed curve, then, by Theorem I., the surface-integral of electric force over any two surfaces bounded by the curve is the same, provided there be no free electricity between them, the integrals being reckoned in the same direction through the curve. And this is true for any vector-quantity which has no convergence. The surface-integral thus depends on the form of the bounding curve only, and we may naturally expect that it can be put in the form of a line-integral taken round the curve. But it is convenient for the demonstration to commence with the line-integral. Let R be any vector, which we may now consider as magnetic force; the line-integral of R once round the closed curve is then the amount of work done by the magnetic force on a unit magnetic pole when it is caused to move once round the curve. If ds is an element of the curve, the work for the path ds is ds × component of force along ds, or $R\cos\epsilon\,ds$, where ϵ is the angle between R and ds; consequently, the line-integral is expressed by $\int R\cos\epsilon\,ds$. We require now to express this in the form of an equivalent surface-integral of another vector over any surface bounded by the curve, and to find what relation the new vector bears to R. The proof that the surface-integral is always possible is easy. Imagine any surface S bounded by the closed curve. As in the first theorem we divided the volume we started with into two, so now we divide the surface S into two, S_1 and S_2, by means of a line joining any two points of the boundary of S. We thus form two closed curves, each having the new line in common. Now reckon the line-integral of force once round both of the closed curves, rotating the same way. In going round the first we move one way along the common path, and in going round the second we move the other way; therefore, the sum of the two integrals is equal to that round the original closed curve, for the integrals for the common portion cancel when added. This device, which is due to Ampère, may be naturally extended. Divide the whole area S into an indefinitely great number of elements, dS; find the line-integral round every element, add together all the results, and the sum is equal to the line-integral once round the bounding curve of S, owing to all the inner line-integrals cancelling. The direction of rotation must, of course, be the same for every element of surface. The elementary part of the equivalent surface-integral is, therefore, nothing more than the line integral of R round an element of surface. To find the exact relation between this and R, it is best to suppose in the first place that the surface S is made up entirely of plane portions, all of which are either parallel to the planes of $y\,z$, or of $z\,x$, or of $x\,y$. Take an element parallel to the plane of $y\,z$, axis along x. The + direction of rotation is right-handed, and the + direction of x downwards through the paper. Now, X, Y, Z being the components of R at the corner P, we have nothing to do with the component X, because it is at right angles to the closed curve. The integrals for the four sides of the square are, starting from P,



$$Y\,dy;\ \left(Z + \frac{dZ}{dy}\,dy\right) dz;\ -\left(Y + \frac{dY}{dz}\,dz\right) dy;\ -Z\,dz.$$

Adding these all together we get simply

$$\left(\frac{dZ}{dy} - \frac{dY}{dz}\right) dy\,dz = X_1\,d\,y\,d\,z, \text{ say.}$$

Similarly, the line-integrals round elements of surface $dz\,dx$ and $dx\,dy$ are

$$\left(\frac{dX}{dz} - \frac{dZ}{dx}\right) dz\,dx \text{ and } \left(\frac{dY}{dx} - \frac{dX}{dy}\right) dx\,dy$$
$$= Y_1\,dz\,dx, \text{ say.} \qquad = Z_1\,dx\,dy, \text{ say.}$$

If, then, we assume X_1, Y_1, Z_1 to be the components of a

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new vector R_1, we have line-integral of R = surface-integral of R_1, provided that the surface is made up as above stated.

But if we diffentiate the three components of R_1 to x, y and z, and then add, we find

$$\frac{d X_1}{d x} + \frac{d Y_1}{d y} + \frac{d Z_1}{d z} = 0,$$

which shows that the new vector has no convergence anywhere, and consequently its surface-integral over *any* surface bounded by the closed curve is the same. Consequently, the theorem (Stoke's) is proved for any surface. We may write it simply

$$\int R \cos \epsilon \, d s = \int\int R_1 \cos \epsilon_1 \, d S \quad . \quad . \quad . \quad (II.)$$

The left side being the line-integral of R, the right the surface-integral of R_1, ϵ the angle between R and the element of curve $d s$, ϵ_1 the angle between R_1 and the normal to the surface-element $d S$; and the relation between the components of R_1 and those of R being those above given.

If R is magnetic force, R_1 is $4\pi \times$ current-density.

If R is the vector-potential of current, R_1 is magnetic force. And, in general, R_1 is the curl of R.

III. There is yet one more connected theorem, which relates to *un*closed curves. If a vector, R, has no curl, the line-integral once round any closed curve is zero, by the last theorem. Such a vector is electric force. Taking, then, two points A and Z on the closed curve, the line-integral of R from A to Z by one path is cancelled by that from Z to A by another; or the line-integral of R from A to Z is the same along any path; it therefore depends only upon the *position* of A and Z, the common terminations of the paths. Let, then, at every point of space the value of a scalar quantity P be given, its values at A and Z being P_A and P_Z, and similarily for any other point. Divide any line joining A and Z into pieces A B, B C, C D, &c., Y Z. Then evidently

$$P_A - P_Z = (P_A - P_B) + (P_B - P_C) + \&c. + (P_X - P\ ) + (P_Y - P_Z),$$

or the difference in the values of P at A and Z = sum of the differences for all the pieces into which the whole path A Z is broken. $P_A - P_Z$ is, therefore, expressible as a line-integral along the path; if ds is an element thereof, the element of the integral is

$$P\, d s - \left(P + \frac{d P}{d s}\right) d s = - \frac{d P}{d s}\, d s$$

Consequently,

$$P_A - P_Z = \int_A^Z - \frac{d P}{d s}\, d s = \int_A^Z R \cos \epsilon \, d s \quad . \quad . \quad . \quad . \quad (III.)$$

This theorem is sufficiently obvious. It is added for the sake of completeness. If P be the electrostatic potential, R is the electric force, and its component $= - \frac{d P}{d s}$ in any direction s. If P be the magnetic potential of electric currents R is the magnetic force, provided that the line of integration does not pass through electric current. For the magnetic force has no curl where there is no current. Magnetic force is, therefore, derivable from a scalar potential-like electric force everywhere except where there is current. But it must be added in this case that $P_A - P_Z$ is only the same for the two paths, provided they do not embrace a current, for if they do, the line-integral of magnetic force once round the closed curve formed by the two paths will equal the surface-integral of the curl of the magnetic force over any surface bounded by the curve, and this surface will have current through it at some places, and there the curl is not zero, but $4\pi \times$ current density.

A comparison of the three theorems is instructive. Starting with the third theorem, we find that the difference in the values of a *scalar* function at the two points = line-integral of a derived *vector* along any connecting line.

Join the points by a second line, thus forming a closed curve, and the second theorem tells us that the line-integral of a *vector* once round it = surface-integral of a related *vector* over any surface bounded by it.

Lastly, let two surfaces have the same bounding curve, so that, taken together, they form a closed surface; the first theorem tells us that the surface-integral of a *vector* over it = volume-integral of a related *scalar* throughout the enclosed space.

Here we stop. Space has but three dimensions, and we cannot make a fourth to please anybody. Starting with a scalar for points, we have vectors for lines and surfaces, and a scalar again for a volume. I am not able to fathom the nature of the corresponding magnitude to be integrated in four dimensions, but probably it does not matter.

PRACTICAL LABORATORY CIRCUITS FOR SECONDARY BATTERY WORK.

In *The Electrician* for the 4th instant there are some notes by Mr. R. M. Bosanquet, in which he describes his difficulties in charging secondary batteries with the Gramme dynamo, difficulties which occur in some degree with all but shunt dynamos, or with those which obtain the current for the field magnets from an exciter.

Mr. Bosanquet's method of charging is to connect the terminals of the machine by a wire of about 5 ohms resistance, then to connect the batteries to be charged in arc with it, and finally to disconnect the wire. But, as he justly remarks, "there is a period of instability at the moment of removing the resistance, and the machine is often reversed before the high speed is established; the only means of obviating this are (1) to cram on every available pound of steam at the moment, (2) to execute the two operations of joining up the battery and removing the resistance in such quick succession that the speed has not time to fall. By the use of both these precautions I have generally succeeded in starting the charging in this form; but until I had acquired considerable experience and a thorough understanding of the conditions I frequently failed."

Now, by Mr. Bosanquet's own confession this plan is at best an uncertain one. There is another difficulty, by the way, which he omits to mention, viz.:—that, if for any reason the charging current is stopped, there is still more difficulty in beginning again than there was at first starting, owing to the batteries having acquired during the previous charging an electromotive force slightly higher than their normal one, probably due to the oxygen and hydrogen occluded at the anode and cathode respectively.

Diagram I. will explain the plan which we employ for charging with the Gramme.

When the movable arm of the 13-way switch S is turned, it touches the next contact piece before it leaves the one it is on at first, thus never breaking the main circuit.

To begin with, this arm is put to the first contact piece, and the current turned on by the main switch A (Diagram II.). If the current is shown by the detector F (consisting of a compass wound with a few turns of thick wire) to be in the wrong direction, A is turned off and the current reversed by means of the pole-changer H. A is then turned on again, and as soon as the ammeter G shows the proper charging current, say 20 amperes, S is slowly turned round, thus gradually bringing in the accumulators, five at a time for the first few, and then by twos and ones until the whole battery is in circuit. There is thus no need "to cram on every available pound of steam" (foot of gas in our case), and, therefore, no sudden strain on the engine, counter-shafting, &c.

There is another convenience in this arrangement, which is that in discharging, the last few cells can be added one by one, as is often required, especially when working incandescent lamps. Diagram II. shows our resistance table, which will be seen to be arranged as follows:—$\frac{1}{8}$, $\frac{1}{4}$, and $\frac{1}{2}$ ohm round the four-way switch B, one ohm between each two contact

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pieces of the sliding switch C, which thus gives from 0 to 7 ohms, and an 8-ohm coil on the three-way switch D.

By this arrangement the resistance can be varied by ·125 ohm at a time, from $\frac{1}{8}$ ohm to $15\frac{7}{8}$ ohms. We employ spring coils one inch in diameter of German silver wire, No. 16 B.W.G., stretched between the table and the floor as shown. They are fastened by long staples, not driven home, so that the German silver never touches wood. Each ohm is joined to the next one, and to the copper wire from its contact piece on C, by a terminal or a Britannia joint.

The simplest method of coiling the wire, if a lathe is not available, is to make a hole in each end of a wooden box, and pass a piece of $\frac{3}{8}$in. rod through, with a handle at one end. (Diagram V.)

When the wire has been coiled close together, it is pulled out considerably beyond stretching point, then slipped over

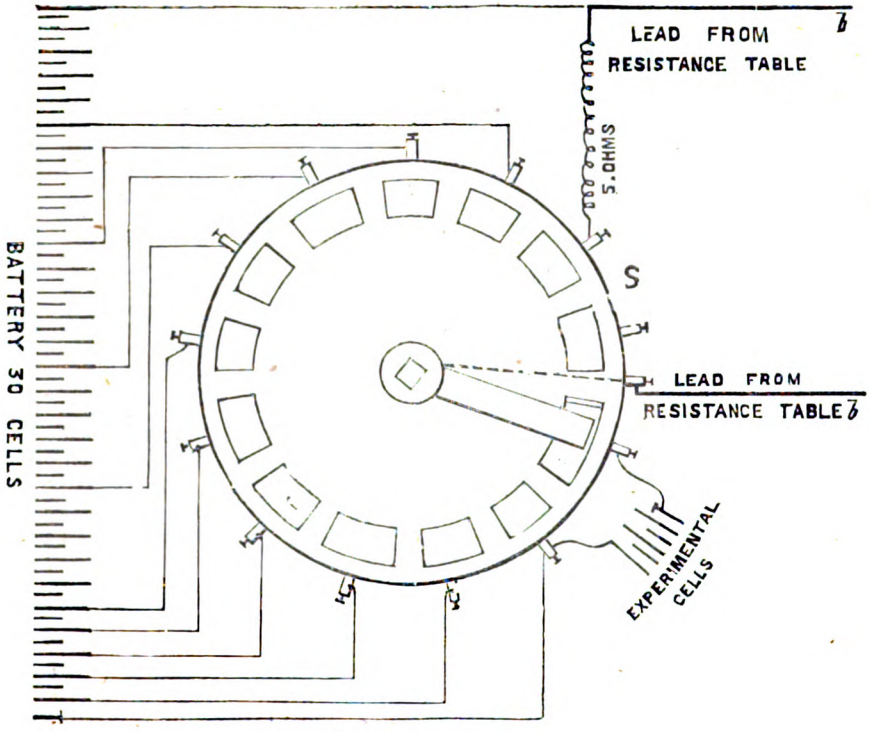

Diagram I.

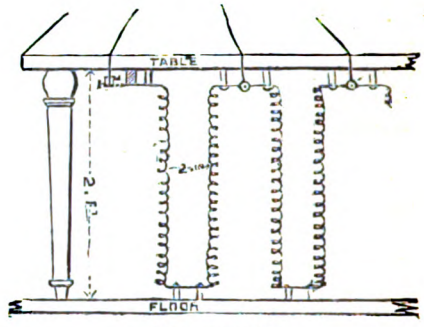

Diagram III.

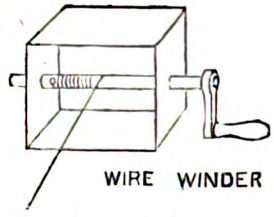

Diagram V.

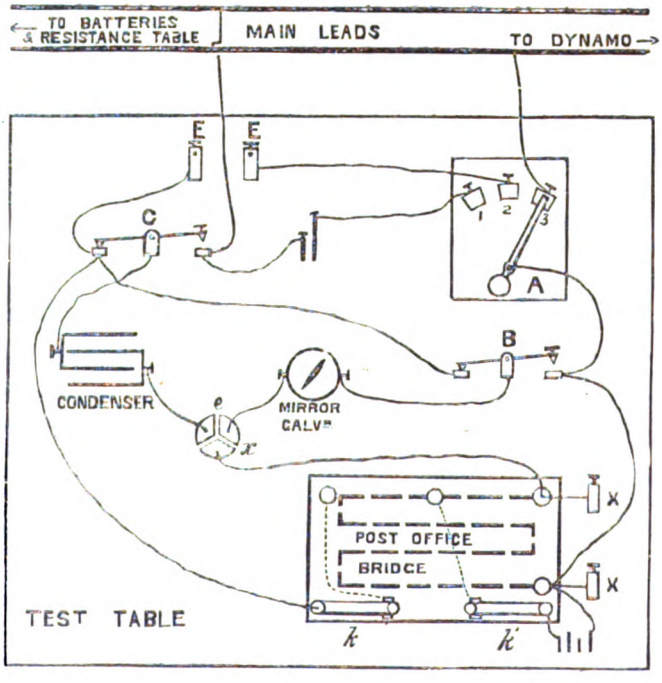

Diagram IV.

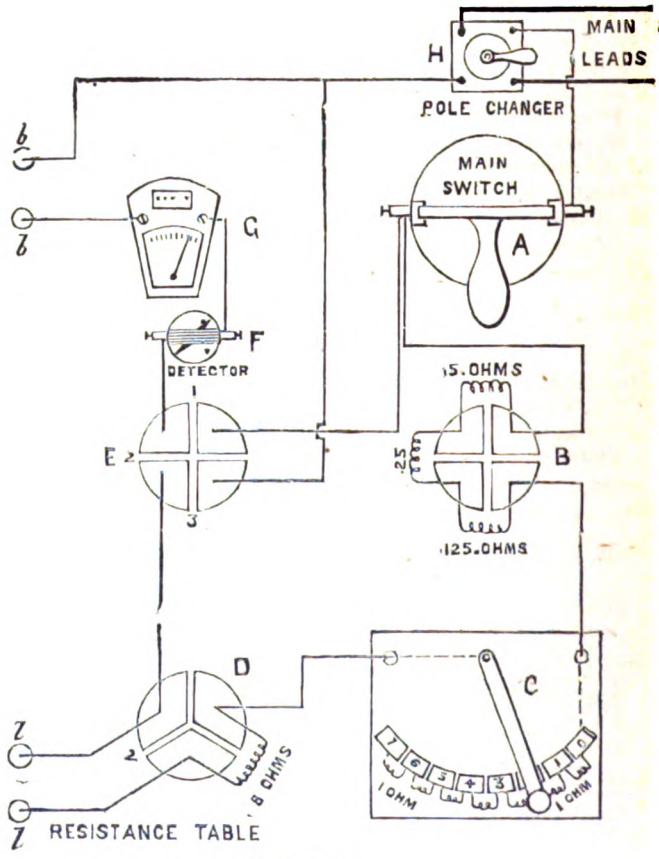

Diagram II.

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the rod again, the coils pressed up together and the handle turned until all is tight again. This will give a perfectly even spring, with the coils about the right distance apart. The middle of each ohm must, of course, be straightened out to fasten to the floor.

Sixteen ohms on this plan only require an area of 22in. × 10in., allowing 2in. between each coil. The ventilation is so thorough that we pass a current of 25 to 30 amperes through No. 16 wire without injuring it, though Mr. Jehl's formula, given in his paper on "Electric Lighting at Brünn," gives 16 amperes for this size.*

As part of the resistance we have a circuit of 25 incandescent lamps, in multiple arc, round the laboratory and adjoining rooms, starting from the terminals *l l*, with a small switch on each lamp. Resistance hot of each lamp = 44 ohms, and current required = 1·2 to 1·3 ampere, so that when we require a resistance of $\frac{44}{25} = 1{\cdot}8$ ohm or more, and a current of $1{\cdot}3 \times 25 = 32$ amperes or less, the plug D_2 is pulled out, the number of lamps being adjusted to the current. Thus if, when charging the batteries with an 18 ampere current, we have to add a resistance in series of $5\frac{1}{4}$ ohms, we use $\frac{18}{1{\cdot}2} = 15$ lamps, $R = \frac{44}{15} = 3$ ohms, and make up the $5\frac{1}{4}$ ohms by using $2\frac{1}{4}$ ohms of wire resistance.

In order to work the lamps in this manner, we plug 2 on the four-way switch E.

Now it is often convenient to have the lamps alight when we have not sufficient E.M.F. to work them in series with the accumulators. By plugging E 1 and 3 we have the lamps together with the wire resistances in multiple arc with the batteries. In practice, we find it almost as easy to regulate the charging current with this arrangement as with the resistance in series with the batteries.

Diagram IV. shows the plan of our test table, which will be found a very simple and convenient one for taking E.M.F. of standard cell, dynamo, battery, and any experimental cell, the internal resistance of the latter two, and any ordinary resistance by means of the bridge. The method of working is as follows:—

Plug *e* for all but external resistance by the bridge.

Switch A to 1, and depress both B and C; this gives throw of the standard cell.

Switch A to 3 and depress both B and C; this gives throw of dynamo if charging, or of battery if dynamo be cut off.

Switch A to 2 and depress B only; this gives the throw on open circuit of any cell connected to terminals E E, and thence its E.M.F., by the well-known formula $E = \frac{a \times 1{\cdot}457}{D}$, where a = throw of cell to be tested and D = throw of standard cell.

The same formula is, of course, employed to obtain E.M.F. of dynamo or battery.

For finding the internal resistance of single cell unplug a resistance R in bridge; depress *k*, then B, obtaining deflection β, when by the usual formula internal resistance $= R\frac{a-\beta}{\beta}$ (a being throw as obtained above).

By introducing the key C we make it absolutely impossible to short circuit or put through the resistance box either the standard cell, the battery, or the dynamo, whatever keys may be accidentally depressed or plugs wrongly placed.

N.B. B and C must both be released before the condenser can be discharged.

It would be obviously impossible to circuit the whole battery through the bridge coils without injuring them, but we may measure its internal resistance with sufficient accuracy as follows:—

Disconnect the dynamo, and on the resistance table (Diagram II.) turn on the main switch A, arrange a suitable resistance on this table, plug E_1 and $_3$, and turn on the 13-way switch to include as many cells as we require the internal resistance of, which are thus circuited through the resistances, the deflection β being obtained before the coils have time to heat perceptibly.

The leads between the battery and the resistance table are so short and thick that their resistance may be ignored.

In employing the test-table for taking ordinary external resistance joined to the terminals X X, plug *x*, and work with the keys *k* and *k* on the bridge box in the usual manner.

C. W. S. Crawley,
School of Electrical Engineering, E. C. Rimington.
12, Princes-street, Hanover-square, W.

* By-the-bye, a more convenient expression for this formula for English electricians would be:—$16\sqrt{I}$ = diam. in mils.

TELEPHONE WIRES AND THE FIRE IN MANCHESTER.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: My attention has been drawn to a paragraph on page 28 of your issue of the 25th inst., respecting a large fire in this city on the 17th.

As the portion of the paragraph has been copied in many other papers, and as its inaccuracy is calculated to do our company great damage, I must ask your permission to send you a reply, in the confident hope that you will insert it in your paper:—

You say—"The warehouse was in the centre of the business portion of Manchester, and, with the exception of the Royal Exchange, was the most important centre of overhead wires in the city. Fully 300 wires converged on the building, or passed over it, and were in the midst of the fire. A few of them broke soon after the fire had heated them, and fell into the street. The main portion held out until the roof of the warehouse fell in, and they were then broken by hundreds, and the ends of most of them fell in a state of white heat into the streets, or on to the roofs of the adjoining buildings. The whole of the telephonic and telegraphic communication with the most important portion of the city was absolutely destroyed. . . . . The hanging wires were a source of great danger for the time being." The *facts* of the case are these: The warehouse in question was not the most important centre save one in the city. Of the 800 exchange and 280 private wires we have in the City only 47 "converged on or passed over" the building in question. Of these five were attached to two chimneys and 42 were fixed to a standard.

Neither the chimneys nor the wires fixed to them gave way at all; the standard fell with the roof, but all the wires fell with the standard, and rested upon the wall eighty feet above the street. Not one of them broke; consequently there were none, either at a white or red heat, dropping into the street. They remained fixed to the head of the standard till the following day, when our own men cut them down with due precautions for the safety of the public.

The telegraphic communication was *not* destroyed, as there was not a telegraph wire on the building, and part of our communication was restored on the Monday morning following, and the whole of it on Wednesday morning.

Allow me to add—as it is now the fashion to wage a bitter war against overhead wires—that during the three years' existence of our company only one wire has broken in this city. This was last winter, when a chimney pot was blown off in a gale, and in its fall it cut one wire, which fell harmlessly and gently into the street.

How different the reality to the imaginary description!—Yours, &c., Joseph Thompson, Managing Director.

Lancashire and Cheshire Telephonic Exchange Co. (Lim.),
38, Faulkner-street, Manchester, Nov. 28, 1882.

DYNAMO FOR BICYCLE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Will you kindly say if there are any dynamo machines made small enough that would fit on the head of a bicycle to light it in place of a lamp? Speed could easily be got to drive it a few hundred revolutions per minute.—Yours &c.,

Soho Foundry, Barrow, Nov. 25, 1882. P. Howell.

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MILITARY TELEGRAPHS IN EGYPT.

In venturing to offer a few remarks on the paper read at the Society of Telegraph Engineers and of Electricians last week we feel, perhaps, like the chairman who presided on that occasion, in a would-like-to-know frame of mind. As civilians, we approach military subjects, even those closely related to telegraphy, with becoming modesty, and a due sense of our presumption in approaching them at all. Still, we would like to know one or two puzzling things about which we are unable ourselves to offer any explanation. And we want to know them, not in the spirit of fault finding, but in order to form a correct judgment upon the value of telegraphy in military movements, and the limits of possible usefulness at critical moments in actual battle.

It is no disparagement to say of Col. Webber's interesting account of the telegraph operations connected with the expeditionary forces in the late Egyptian war that it did not afford any explicit information on these points. That the telegraphs were extremely useful to the public we all know; that their maintenance was a task of considerable difficulty we can well believe; but that they were of great service to the army is a point still left in some uncertainty. Colonel Webber being a military man, and on active service in this campaign, laboured under two disadvantages in giving an account of his stewardship to a non military and irresponsible audience. As became a man of war he was silent, or at all events not communicative, on those very points which would have interested his hearers most, namely, personal narratives; and as a servant of the War Office he was reticent on just those matters of organisation and administration which would have been considered most instructive. This was unavoidable, and even commendable; but on that very account the lecture left a sense of something lacking, something which any "special correspondent," for example, with a quick eye and a ready pen, might have easily supplied. Nor was this all; there were some conspicuous gaps in the narrative, and one or two quite surprising episodes, which not unnaturally provoked the would-like-to-knows referred to above.

We would like to know, as did the chairman of the meeting, how it happened that the officer, who in our ignorance we fondly supposed was in sole charge of the military telegraphs, arrived at the enemy's deserted telegraph office alone. An ideal operation would have been so planned that a party of military telegraph constructors and manipulators should follow close on the heels of the advancing British lines, ready, so to speak, to join the Kantara wires to those communicating with Cairo; possibly, also—by prearrangement—with Alexandria. Somebody at least, one might have supposed, would be in readiness to work the circuits as if nothing had happened, to send delusive messages, if such a course seemed expedient, or at any rate to read whatever signals appeared on the wires. We do not presume to say that it would have been better if this had been done, and we are ready to admit, on proof shown, that things turned out just as well as they were. What we mean is that the ideal arrangement was not carried out, and we are still wondering why it was not. What really happened was that one officer of the Royal Engineers' Telegraph Corps found himself in possession of an important line of communication—in the telegraphic sense of the word—unable himself to work it, and with nobody belonging to him within reach. That there was no want of foresight is evident from the officer himself making straight for his mark. No lack of presence of mind either, for a couple of Highlanders were promptly laid hold of to put the leading wires in order. "Highlanders!" inwardly exclaimed the audience, "where were Colonel Webber's own men—those highly-trained and incomparably smart men who can turn their hands to anything in the matter of telegraphy, from digging holes and staying poles to keying messages and adjusting relays?" Blue jackets and Highlanders are admirable men; Colonel Webber had to make use of the former on many occasions, and of the latter on a critical one; but they are not the military telegraphers on whose training and equipment so much pains have been bestowed. Fortune favours the brave; and at the Tel-el-Kebir telegraph station—if we understand the account correctly—she came in the shape of a couple of battle-stained warriors in plaids, and a somebody else belonging to the Intelligence Department, who providentially could work a Morse instrument, and had scented it out in the fray. That the corps, a portion of it at least, which might have followed its adventurous chief, was not unemployed on that eventful morning we are quite sure. We know that some of them were with the telegraph waggons on either flank of the attacking force, for one of the men has

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been decorated on account of services so rendered in the action. But as to the rest, they may, for all we know, have been impressed into the fighting lines, leaving the telegraphs to their fate. And this conjecture seems the more probable when we learn that the Royal Engineers in this campaign were in reality commanded by an officer who was not a telegraph engineer at all.

We have no military opinion to offer on the fact just mentioned; but, from a telegraphic point of view, it does seem as if somebody in high authority set very little value on the employment of electricity in the operations of warfare. There is no doubt something to be said on the other side. For the moment the success of an attack is of first importance, and every additional man contributes to the certainty of success. Perhaps, also, nobody suffered by the temporary withdrawal of the men—if they were withdrawn, for we speak on surmise—except those incurably frivolous persons who, it seems, are as common in the army as elsewhere, and who therefore regard telegrams as indispensable even on a field of battle. Something was said about this class of people, and the inconvenience they occasioned by rendering censorship a most arduous duty to prevent a complete blockage of traffic. To a commanding officer for whom the statistics of telegrams forwarded and received during a campaign have no interest whatever, this luxury of the telegraph, we can quite believe, may appear a not unmixed boon. A certain rough-spoken general once shouted to a kilted regiment among the furze bushes, "If you don't kneel properly I'll put you in breeks, and be blank to you!" In some such spirit a non-telegraphic engineer may treat all sumptuous provisions for sending telegrams to friends at home from the battle field. One can fancy him saying, If you want to send a message send it yourself—*if you can*.

And this reminds us of one other little bit of information which casually came to light in Colonel Webber's discourse. We refer to the importance of officers as well as men being able to work the telegraph when they have got it. Every administrator of telegraphy knows the value of this accomplishment, whether he possesses it himself or not; to every military officer of field telegraphs its acquisition ought to be an imperative duty. Of this we are perfectly sure, although we are only civilians who say it. We confidently appeal to the experiences of this campaign in Egypt in proof of our assertion. Cases must often arise—did arise, we believe—when some ticklish operation with which an officer of rank ought alone to be trusted has to be performed by a subordinate, as well as cases where an officer gets isolated, and is, consequently, useless if he can neither work nor read the instruments skilfully. We venture to commend this frank expression of opinion with all respect to those whom it may concern.

It was exceedingly gratifying to hear that the expedition went out with a telegraph equipment perfect and complete beyond anything ever attempted before. But, on the whole, we are inclined to think that a civilian or semi-military corps of telegraphers, not liable to be called to do duty as soldiers except in self-defence, would be a useful adjunct to any future expedition. Mr. Patey, the secretary of the post office telegraphs, informed the meeting that he had had numerous offers from volunteers, and there would, therefore, be no lack of men if their services should ever be desired. Be that as it may, the experience gained by an accomplished and energetic officer like Colonel Webber cannot fail to be turned to good account between now and the next campaign.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are contributed by E. C. Rimington, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

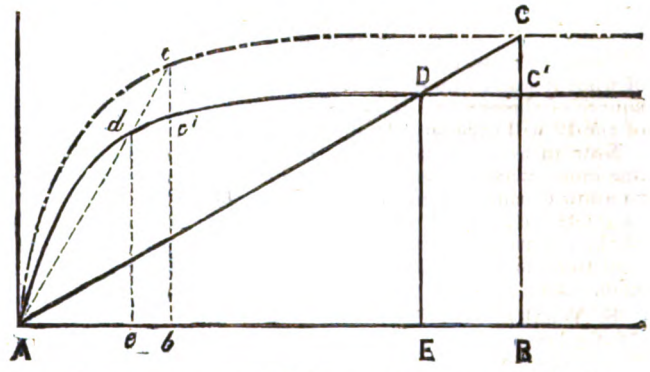
6. What is the E.M.F. in volts of a Daniell and of a Grove cell? What is the E.M.F. of the dynamo you are best acquainted with, running at some definite speed, and with some special resistance in circuit? How, exactly, is this E.M.F. altered by increasing the speed? In the case of a magneto machine, how does the E.M.F. vary with the speed? Explain fully the cause of the difference, if any, in the effect of speed on E.M.F. in the dynamo and in the magnetic machine.

Ans. The E.M.F. of a Grove cell = 1·97 volts.
" " Daniell " = 1·079 "

The next two parts of this question would hardly be of interest to our readers.

With regard to a magneto-machine, the E.M.F. varies in direct proportion to the speed, provided the exciting current remains constant.

In a dynamo, on increasing the speed, the E.M.F. will increase in a greater ratio, provided the resistance in the circuit be kept constant, as long as the current generated is not sufficient to saturate the field magnets. When, however, this is the case the E.M.F. becomes approximately proportional to the speed. This may be shown in the diagram.



Here A *d* D represents the characteristic curve of the dynamo for the lower speed, and A *c* C that for the higher, A *e* and A *b* represent the current, and *b c* and *e d* the E.M.F. in both cases. The resistance in each case is represented by tan *c* A *b*, here *b c* > *e d*.

Now, when we come to the flat portions of the curves, which represent the field magnets at their points of saturation, A B represents the current for the higher speed, and A E for the lower, the E.M.F.'s are represented by the lines C B and D E, but in this case E D = B C.

In a magneto machine, when the exciting current is kept constant, the magnetic force of the field magnets is also constant and entirely independent of the speed.

9. Describe in detail the construction of the incandescent lamp you are best acquainted with, and explain how the various types of incandescent lamps differ from one another.

Ans. We may divide incandescent lamps into two classes, viz.: those composed of natural fibres, and those composed of fibres chemically treated in order to render them more dense.

Of the former, the Edison, consisting of carbonised bamboo, the Maxim of carbonised cardboard, and the Lane-Fox, in which the fibre is made from carbonised "Monkey Bass," such as is used in carpet brooms. Of the latter, the Swan, in which a fibre of crochet cotton gelatinised in a dilute solution of sulphuric acid, and then carbonised is employed, and the FitzGerald, where paper is treated with a solution of zinc chloride, then compressed, and finally carbonised, is employed as a fibre.

10. A Grove battery of 20 cells will light from one to twenty ordinary lamps in parallel circuit, but the *fewer* the lamps the *more* the light given out by each. On the other

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hand a Gramme machine will not light one ordinary incandescent at all, but will light twenty or thirty well. Explain fully what this difference depends on.

Ans. This difference arises partially from the fact that the Grove cells have to be joined up in series in order to obtain sufficient E.M.F. at the terminals of the lamps, consequently the internal resistance amounts to something considerable. When one lamp is being lit the current through it is (*e.g.*) one ampere, when we add another in parallel circuit with the first the total current is rather less than two amperes, giving not quite one ampere through each lamp. Now, when we add 20, the total current is considerably less than 20 amperes, thus we do not obtain a current of nearly one ampere through each lamp.

Let C = the current when we have one lamp in circuit.
„ C_1 = total current when we have n lamps in circuit.
„ c = current through each lamp when we have n lamps in circuit.
„ R = resistance of each lamp.
„ ρ = internal resistance of the battery.
„ E = actual E.M.F.
„ n = number of lamps in parallel circuit.

Then
$$C = \frac{E}{\rho + R},$$
$$C_1 = \frac{E}{\rho + \frac{R}{n}},$$
$$c = \frac{I_1}{n} = \frac{E}{\frac{\rho + \frac{R}{n}}{n}} = \frac{E}{n\rho + R}.$$

Let us suppose R = 30, and $\rho = 2$, $n = 17$.
When we have one lamp in circuit,
$$C = \frac{E}{32};$$
when we have 17 lamps,
$$c = \frac{E}{34 + 30} = \frac{E}{64}.$$

Thus the current through each of the 17 lamps is only one-half of what it was through the one lamp, and as light varies as the square of the current, if the one lamp gives 16 candle-power each of the 17 will give only 4 candle-power.

Now, in working the lamps from a dynamo, the resistance of one lamp, which is not likely to be less than 40 ohms, is too high to allow of sufficient current being produced to excite the field magnets; if, however, we add 19 more, we reduce the resistance of the external circuit to two ohms, thus allowing a strong current to be produced amply sufficient to saturate the field magnets. This, of course, does not apply to a shunt dynamo.

8. What are the essentials of a good electric lamp? How does a lamp for reverse currents differ from one for direct currents? What also is the difference between the carbons employed in the two cases?

Ans. The essentials of a good electric arc lamp are that the carbons should be maintained at a distance from each other, which gives the best arc as the current varies. The lamp must also be provided with a convenient arrangement for bringing together the carbons when the circuit is broken, and allowing them to separate to the proper distance for forming an arc when the current recommences. A good lamp should give as steady a light as possible, and not consume much more current than is necessary to produce the light. In a lamp for reverse currents the carbons are both consumed equally, while in one for direct currents the positive carbon is consumed about twice as fast as the negative. Lamps for alternating currents are generally arranged on the differential principle, in which the main coil and the shunt coil are arranged one above the other, the effect of one on the armature core being thus partially counteracted by the other.

MOTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you or any of your readers tell me where I can get a few electric motors specially designed to drive shafting and very light machinery?

I want from five to six horse-power at 1,200 to 1,500 revolutions per minute, and I would like something more portable than the ordinary reversible dynamo.

If you will kindly help me I shall be grateful.—Yours, &c.,
W. H. MASSEY.

Twyford, Berks., 27th November, 1882.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

IX.

We have thought it better to defer the consideration of the working out of particular tests till we have gone over the practical execution of those which we may call "regular," as distinguished from special operations, proposing to discuss that part of the subject in a number by itself. For this reason we have not fully worked out a "capacity" test, which will, however, be treated of in its place.

We are now about to treat of the subject of measuring insulation as applying to a cable, having already touched upon it in Numbers IV. and V. when showing how this quality is observed by means of the quadrant electrometer. The operation is called a test for insulation resistance; this is in some respects a misnomer, and one uninformed on the subject might imagine it meant the quality of resisting insulation, whereas it means just the reverse. When testing the insulation resistance, we measure the degree in which the insulation resists that which tends to reduce or oppose it. An analogy exists between conductive resistance and insulation resistance with reference to a cable. The former is a feature of the copper conductor and the latter of the insulating envelope, but we do not regard both of them in the same light. As a quality, the one is not on all fours with the other. Conductive resistance in this respect is not a desirable feature, whereas insulation resistance in its true meaning is to be commended. In measuring the first the less there is of it, generally speaking, the better, but the latter is all the more desirable the higher or greater it is. We look for small resistance in the conductor, but the contrary in the insulating cover. It must also be remarked that the proportion

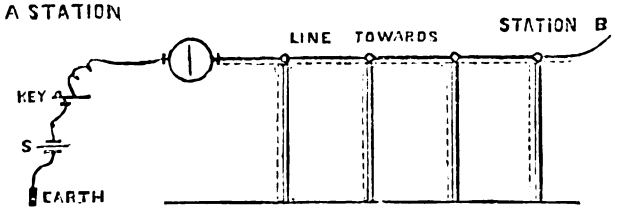

FIG. 18.—Leakage on a Land Line. Current passing.

between the resistance of a length of cable and that of any part of it is on exactly opposite conditions in the two cases. In a length of ten miles, for example, the copper resistance of the whole is ten times that of each mile, supposing it to be perfectly similar throughout; but the insulation resistance of the whole ten miles under the same limitation is only 1-10th that of each mile. The reason of this appears at once if we alter the expression in the latter feature, and say, "the resistance to insulation, or the *leakage*" is ten times greater for ten miles than for one or each mile. Every mile of the conductor has its 1-10th of resistance, and the whole ten has ten times the quantity. So with the leakage—every mile adds to the amount, and the result is the same. But the opposition to leakage, or the resistance called insulation resistance, is less for every added mile. Of course there would be ten times as much resistance to leakage in each mile as there is for the whole ten; for there are ten portions, each of which weakens or lessens the resistance. We are not concerned with land lines in these papers, at least at this point, or we might show that the conditions governing their qualities are the same as for submarine cables, that is to say, leaving out of the question the insulating supports. A glance at Fig. 18 will bring the matter out clearly. The dotted lines show the leakage.

The insulation resistance can be measured either by the galvanometer or the electrometer and by various tests in both instances. We shall show how to take the test with both instruments, giving at first one method for each. At a later stage we shall have to consider other modes of testing, the more ordinary operations being appropriate at this point. The galvanometer test will first claim our attention, and we have already introduced the electrometer as a means of observing insulation. At the same time the learner is reminded that we have only shown how to observe but not how

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to measure the quality. We must point out that all these so-called measurements are really only comparative; we merely compare one observation with another. For example, by observing what result a known quality or measurement gives under certain conditions we find what an unknown similar measure is by the results it gives under similar conditions. Take the capacity test as an instance. The known capacity of the condenser gives us a certain deflection; by comparing the deflection for the cable we find its capacity also.

After this manner the insulation resistance of the cable is measured. We start with the determination of a standard to which the cable is to be compared. The technical expression is "finding the constant." This word in its application to our immediate subject requires some explanation, which will precede the actual operation; we shall reach the point very shortly.

Now, it must be remarked here that in speaking of the insulation resistance of a cable, we are dealing with resistance of very great amount. To realise this truth we must have some idea of the meaning of the test; its theory demands a moment's thought. Authorities are not absolutely agreed on this point, the process is differently explained. But the simplest way of looking at it fortunately coincides with the opinion of the person best qualified to pronounce upon such matters, as we think, and the view is this: When we take an insulation test we are doing pretty much the same thing as when we take a copper resistance test. The difference lies in the fact that the resistance is comparatively small in the latter case, because the material we deal with is very different. Moreover, the resistance is constant in the latter case and increasing in the former. The units with which we measure are the same, but we have hundreds in the one case, and hundreds of millions in the

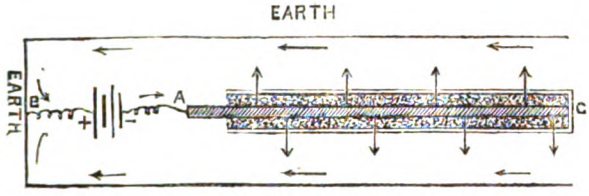

FIG. 19.—Cable Charged. Circuit through Insulating Cover.

other. The best way of regarding substances with relation to their conducting or insulating qualities is to say that a good insulator is a bad conductor of electricity. A good conductor presents small resistance, a good insulator presents very high resistance; and as in all cases of measuring electrical force a complete circuit is established reaching from one battery pole, through all the conducting path round to the other pole, an insulation test, so called, involves the existence of such a circuit, which we will therefore proceed to trace. See Fig. 19. Here the circuit is marked with arrows, and we trace it from the negative battery pole to A at one end of the cable whose other end is insulated. The cable is supposed to be under water, and as we are, for the sake of illustration, regarding the case as one in which a current is established, the conductor must have the means of connection with earth, as otherwise there would be nothing beyond an accumulated charge. The circuit then is continued from the copper conductor through the insulating cover to earth, and this at every point of the surface. We cannot represent this correctly, but must be content with allowing a few points to do duty for the whole, and mark the path with the arrows continuing the circuit to the other pole of the battery by way of the earth connection at B. The case is in this way analogous to an ordinary circuit through a copper wire to earth at one end, with one battery pole also to earth. We do not intend to say that this view completely explains the operation when insulation resistance is measured. It is sufficient to give an idea of what takes place, and by and by we shall consider the matter more closely.

The connections for the test will be exactly the same as those in Fig. 16 for the capacity test, but a large number of cells will be used, from 100 to 300, according to their nature and electromotive force. The cable will be connected up as before in either of the ways pointed out. It is sufficient for our purpose to suppose it joined at B in the galvanometer commutator (Fig. 16A). The ordinary insulation test is commonly taken with the negative current, the positive current being most generally used when reversal tests are taken, as we shall show further on. The reason for this is, briefly, that a negative current is regarded as more searching, and as giving a more faithful indication of the condition of the cable than the positive current. The latter tends to conceal or heal up any fault, and, therefore, the former has the preference, though no idea of anything wrong is suggested.

We shall first go through the operation by charging and observing the results which follow in order to give as clear a view as possible of the conditions, and afterwards take the test in regular form. We must premise, however, that in practice we could not safely do this with the cable, because it ought to be quite free of all electrical charge when testing its insulation, and if we once charge it with, say, 200 cells, it would be necessary to put it to earth for a long time, an hour or two or more, perhaps, to discharge it thoroughly. We shall, therefore, to avoid repetition, and at the same time to proceed with a necessary part of the operation, suppose the cable removed from B, and a high resistance put in its place. This resistance will be a million ohms, or a *megohm*, and is the standard to which we are to compare the results given afterwards by the cable. This is the value commonly used for the purpose, and by which we determine the "constant" mentioned above. It is defined as the "constant of the galvanometer with a given battery power." As the insulation resistance of the cable is very great we require an extremely high standard for comparison, and by the device now under notice we obtain a value amounting to many thousand millions of ohms. The constant, literally speaking, is "that number of ohms, or rather of megohms (millions of ohms) which it would be necessary to have in circuit with our* galvanometer and battery in order to cause a deflection of one division to appear on the scale." Of course, we have no such resistance in any form of coil or otherwise, but by using a megohm and introducing a shunt into the circuit we can get such a deflection on the scale as would, when multiplied by the multiplying power of that shunt, amount to the required value. This will appear from observing the operation of taking a constant; meanwhile, any apparent difficulty in grasping the truth is much lessened by remembering that the quantity of electricity passing in a given time through a conductor is *inversely* proportional to the resistance of the circuit; in other words, the strength of the current decreases as the resistance increases, and as the deflections on the scale represent the strength of the current, the smaller the resistance is the larger will be the deflection in any one instance. The "constant" is called the co-efficient for one division, and its value in ohms is found by passing a current through a megohm with necessary shunt, thus getting a certain deflection; then, by multiplying that deflection by the multiplying power of its shunt, we have the resistance of the constant in megohms or millions of ohms. For example, if the deflection were 300 and the multiplying power were 150, the constant would be 45,000 millions of ohms. This amount (45,000) represents the number of divisions the deflection would have given without a shunt when there was a resistance of one million in circuit. From this it clearly appears that if 45,000 millions had been in circuit the deflection would have been one only. The meaning of the operation is that, with the particular battery power

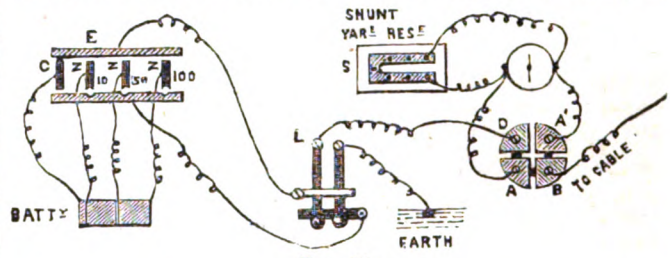

FIG. 16A.

* By this is meant "that particular galvanometer and battery power."

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employed, the current through a resistance of one million ohms causes the galvanometer we are using to give a deflection of 45,000 divisions when the whole of the current passes through it. We purposely leave the resistance of battery and galvanometer out of this calculation as relatively so small.

The learner may be somewhat puzzled at first to understand the real proportion between the divisions (of the scale) and the resistance. We may say that one division represents a million, since 45,000 divisions gives us 45,000 millions for our constant, but by keeping in mind the inverse ratio there will be no confusion. The best way is to consider the divisions as running from one upwards, and the resistances in millions as running from 45,000 downwards. Suppose the constant were only 10 millions, then one division would represent 10 millions, and by placing the figures in two rows we shall see the ratio. Thus:—

$$\begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10. \\ 10 & 9 & 8 & 7 & 6 & 5 & 4 & 3 & 2 & 1. \end{matrix}$$

In the case of our constant of 45,000 millions, each division upwards on the scale represents a million less resistance, till at the 45,000th we have the one million which gave us the deflection $300 \times 150 = 45{,}000$.

Many operators can take an insulation test, and, therefore, know how to get a constant, but many of them do not know, or do not stop to think what it really is. Its usefulness consists in giving us a standard to which to compare the cable. If we know what amount of resistance one division represents in a given instance, we can easily determine that of the cable by observing what deflection results from keeping a current passing through its insulating cover.

THE ELEMENTARY PRINCIPLES OF ELECTRICITY.

II.

The fact that amber and some other bodies, when rubbed, acquire the power of attracting light objects was known to the ancients, and was mentioned by Thales, of Miletus, about B.C. 600. It was also referred to by Theophrastus and Pliny. The latter philosopher also mentions the shocks given by the electric torpedo. During the middle ages some few isolated observations were made, which can only be explained by the excitation of electricity by friction, but these observations do not appear to have led to any experimental inquiry. Dr. Gilbert, of Colchester, physician to Queen Elizabeth, may properly be regarded as the founder of the modern science of electricity. Gilbert found that a great many substances, a full list of which he enumerated, were capable when rubbed of attracting a light metal needle, which was balanced on a point, but that the readiness with which this attraction could be exhibited depended on the hygrometric state of the air. Other substances refused to exert any such attraction. To Gilbert we owe the word *electricity*, and he called those bodies in which the power of attracting light bodies could be excited by friction "*electrics*." Bodies in which this power could not be so excited he called "*non-electrics*." This distinction we shall presently find is without a scientific basis. The first electric machine was constructed by Otto von Guericke, who also discovered electric induction. Newton was the first to employ a glass globe, with which electricity was produced by friction against the hand, and Hawksbee employed a similar generator. In 1729 Stephen Gray discovered electric conduction, and subsequently succeeded in conveying electricity to a distance of several hundred feet by means of thread supported by silk strings. Desaguliers pointed out that the reason why some bodies could not be electrified by friction was due to this conducting power, which caused the electricity to escape as fast as it was generated. Early in last century Dufay showed that all bodies could be electrified if supported on an insulator or non-conductor. He also discovered the dual character of electrification, showing that the electrification generally excited upon glass by means of friction, which he called vitreous electricity, is opposite in character to that excited upon sealing wax, and that bodies similarly electrified repel one another, while bodies electrified in opposite ways attract each other. As the electric machines employed by Newton and Hawksbee furnished vitreous electricity much more readily than resinous electricity, it came to pass that when the terms positive and negative were applied to the opposite kinds of electricity, that furnished by glass was called positive and the other negative.

The substitution of a blown cylinder for Newton's sphere, of a leather cushion covered with silk—over which a metallic amalgam was spread by the help of a little grease—for the hand, and the addition of the prime conductor and the silk flap, which by its negative electrification serves to diminish the tendency of the positive electrification of the glass to run back to the rubber, completed the cylinder electric machine, which is too familiar an object to require a detailed description. By the friction of the glass and the amalgamated rubber the glass becomes positively electrified, while the negative electrification of the rubber is allowed to escape to earth as the positively electrified glass recedes from it. As the cylinder is turned the electrified rubber attracts the oppositely electrified glass, resisting its motion, and work has to be done by the operator against the electrical attraction, the work so done corresponding to the electrical energy of the machine. Besides this the positive electricity on the glass tends to creep along its surface back to the rubber, and if the attraction become very strong, it will fly back in sparks before it gets far away from the rubber. The silk flap, however, becoming negatively electrified exerts a counter attraction, and thus induces the electricity to remain on the glass until it has got so far from the rubber that it is unable to return. It then reaches the end of the silk flap, and is shortly afterwards presented in front of the prime conductor.

The action of the prime conductor affords an example not only of electric induction but also of the behaviour of points. When the positively electrified glass comes opposite to the points of the prime conductor it attracts negative electricity from the conductor, which, rushing off from the sharp points, neutralises the positive electricity of the glass, but leaves the conductor itself charged with positive electricity. The sparks taken from the conductor of this machine serve to ignite gun cotton, alcohol, &c.

Two theories have been proposed to account for the behaviour of electrified bodies. The two-fluid theory was first clearly stated by Symmer; the one-fluid theory was first proposed by Sir Wm. Watson, subsequently developed by Franklin, but more completely by Œpinus and Henry Cavendish. According to the two-fluid theory there exists in every body a combination of two electric fluids, which are exactly opposite in their qualities, so that, by combining in equal quantities, they completely destroy one another's effects, and no test with which we are acquainted serves to detect the presence of the so-called neutral fluid. In this respect they resemble positive and negative quantities in algebra, which, when numerically equal, produce zero by addition. For the reason mentioned above vitreous electricity is regarded as positive, and resinous electricity as negative. Every unelectrified body is supposed to contain equal but unlimited amounts of each of these fluids, which, however, resemble fluids only in their power of *flowing*, and are not to be endowed with mass or any of the other properties of ordinary fluids. Like kinds of electricity repel and unlike kinds attract one another with forces proportional to the product of the charges, and inversely proportional to the square of the distance between them, the dimensions of the charged bodies being supposed very small compared with their distance from each other. A body may be positively charged by giving it positive electricity, or by subtracting from it negative electricity, or by both these operations.

According to the one-fluid theory of electricity, as developed by Œpinus and Cavendish, every body in its normal condition consists of a combination of matter with a definite proportion of electric fluid. For want of any reason to the contrary the electric fluid is identified with positive or vitreous electricity. A body which contains more than its normal charge of electricity is said to be positively electrified; one which contains less than its normal

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charge is negatively electrified. Hence that which is regarded as pure matter in this theory is matter negatively charged to the highest degree of which it is capable. We have no experience of matter in this condition. The theory also supposes that the electric fluid repels itself, but attracts matter, while matter, of course, attracts the electric fluid in return, but repels itself. The hypothesis that matter repels itself was necessary to explain the repulsion existing between negatively electrified bodies. This was considered by some to contradict Newton's law of gravitation; but it must be borne in mind that the law of gravitation has been proved true for matter as it exists in nature, that is, combined with its normal proportion of electric fluid, and not for matter negatively electrified to the highest degree of which it is susceptible. Between two bodies, A and B, according to the one-fluid theory, there exist four stresses, viz., repulsion between the electricity of A and that of B, repulsion between the matter of A and that of B, attraction between the electricity of A and the matter of B, and attraction between the matter of A and the electricity of B. In the case of bodies which possess only their normal charge of electricity, the repulsions very nearly balance the attractions, but we may suppose that the attractions are very slightly in excess, the difference corresponding to the attraction of gravitation.

The law of electrical action, viz., that the attraction or repulson between two charges of electricity is directly proportional to the product of the charges, and inversely proportional to the square of the distance between them, was first shown to be approximately true by Coulomb's torsion balance. In this apparatus a small ball was attached to the end of a shellac rod, which was suspended by a fibre from a torsion head, and was repelled by means of a fixed ball charged with electricity, the balls having first been brought in contact so as to distribute the charge between them. The repulsion at different distances was measured by the twist which had to be communicated to the fibre in order to maintain the balls at each particular distance from each other.

But Cavendish proved "the law of inverse squares" experimentally by a method which admits of far greater accuracy than the employment of the torsion balance of Coulomb. Cavendish showed that no electricity exists on a conductor placed inside a closed conducting sphere, and in metallic communication with the sphere, however highly the sphere may be charged. Now, it can be shown that if the law were other than that of the inverse square of the distance this could not be the case. If, for example, the force varied inversely as the distance, or according to any inverse power lower than the inverse square, the interior of a positively electrified conducting sphere would be electrified negatively, while if the law were that of the inverse cube, or any inverse power higher than the inverse square, positive electricity would be distributed throughout the interior of a positively electrified sphere. As it is possible, by modern electrometers, to detect the *millionth* part of the charge which may conveniently be given to a conductor which is inside a hollow sphere, and which may be put into communication with the sphere, or insulated at will, this method of Cavendish affords a most delicate test of "the law of inverse squares." An experiment of a similar character was performed by Faraday on a very large scale. Faraday built a cube of nine feet edge, and having insulated it he placed lighted candles, electrometers, &c., within. He then remained inside the cube while it was charged by an electric machine until long sparks passed from its edges, but no trace of electrification could be detected by any of the instruments within the cube.

Having thus experimentally proved the truth of the law of inverse squares, we may base upon this law a system of absolute units for the measurement of electrostatic quantities.

Def. The unit of electricity is that quantity of positive electricity which, acting *through air* upon an equal quantity at a distance of one centimetre, repels it with a force of one dyne.

This unit may be roughly realised experimentally by taking two lead shots, each weighing one gramme, and suspending them from the same point by two very fine fibres, each 490·5 centimetres in length. Now, if we suppose the acceleration produced by gravity to be equal to 981 centimetre-second units, the weight of a gramme will be equal to 981 dynes, and the force required to deflect a gramme when suspended by a thread 490·5 centimetres long, through a horizontal distance of ·5 centimetre, will be sensibly equal to one dyne. Hence, if the shots be electrified till each hangs ·5 cm. out of the vertical line through their common point of suspension, and the shots are, therefore, one centimetre apart, the horizontal repulsion between them will be equal to one dyne. The charges of electricity upon the shots will then each be equal to the unit of electricity as defined above.

In defining the unit of electricity it is important to state that the action is supposed to take place *through air*. If the repulsion take place through other non-conducting media (or *dielectrics*, as they are called when considered with reference to the transmission of electric stress through them) such as glass, sulphur, resin, shellac, paraffin, liquid, hydrocarbons, &c., the quantity of electricity required to exert a force of one dyne on an equal quantity at a distance of one centimetre is much greater than when air is the medium through which the stress is transmitted. This is due to what is called the *specific inductive capacity* of the dielectric.

STORAGE BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Permit me to tender my sincere thanks and congratulations that you have so timely commenced a series of papers for beginners in this week's issue. It is just what I have been looking for. I am pleased at the way you have commenced, and with what you promise us in the future. May I ask you to be as explicit and full as you can find time and space for, and may you lead us from the rudiments on into the higher branches of the subject. I should feel much obliged if you will kindly answer the following:—

I have a friend who has fitted up two small installations of incandescent lamps, and in both cases circumstances are such as to render the use of storage batteries especially needful and welcome. But my friend tells me there are none to be obtained. Although advertised, &c., he says the company will not sell batteries to any one, they merely doing a money-market exchange business. He applied for a ton, but could not get them for love or money. Now, here is the point I wish for information upon. I am constantly reading in your paper of storage batteries being used, and this week I see Crompton and Co. are fitting up some lamps on ship board, and are going to supply batteries for the same. Will you kindly tell me how these people obtain batteries. Is it possible to get them by any means?—Yours &c.,

106, Western-road, Brighton, Nov. 27. F. Cowley.

OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am but a tyro in electrical science, and Ohm's law, as laid down by most text writers, puzzles me.

$$C = \frac{E}{R}.$$

That means, as I understand it, that current or available force equals the electromotive force divided by the resistance. Now, assuming that E is 12 and R 2, it follows that C = 6, and if E is 12 and R 4, C = 3, in the one case a reduction of 6 where the resistance is 2, and a reduction of 9 when the resistance is 4. Now, why 2 should make a reduction of 6, and 4 only make a reduction of 9 is what I cannot exactly comprehend. I have my own notion of what the real fact is, but as that involves a contradiction of what is so universally admitted as truth, I should be very conceited if I did not think I am under some mistake. Perhaps some of your skilled readers will kindly enlighten me.—Yours, &c.,

Nov. 24, 1882. J. A. S.

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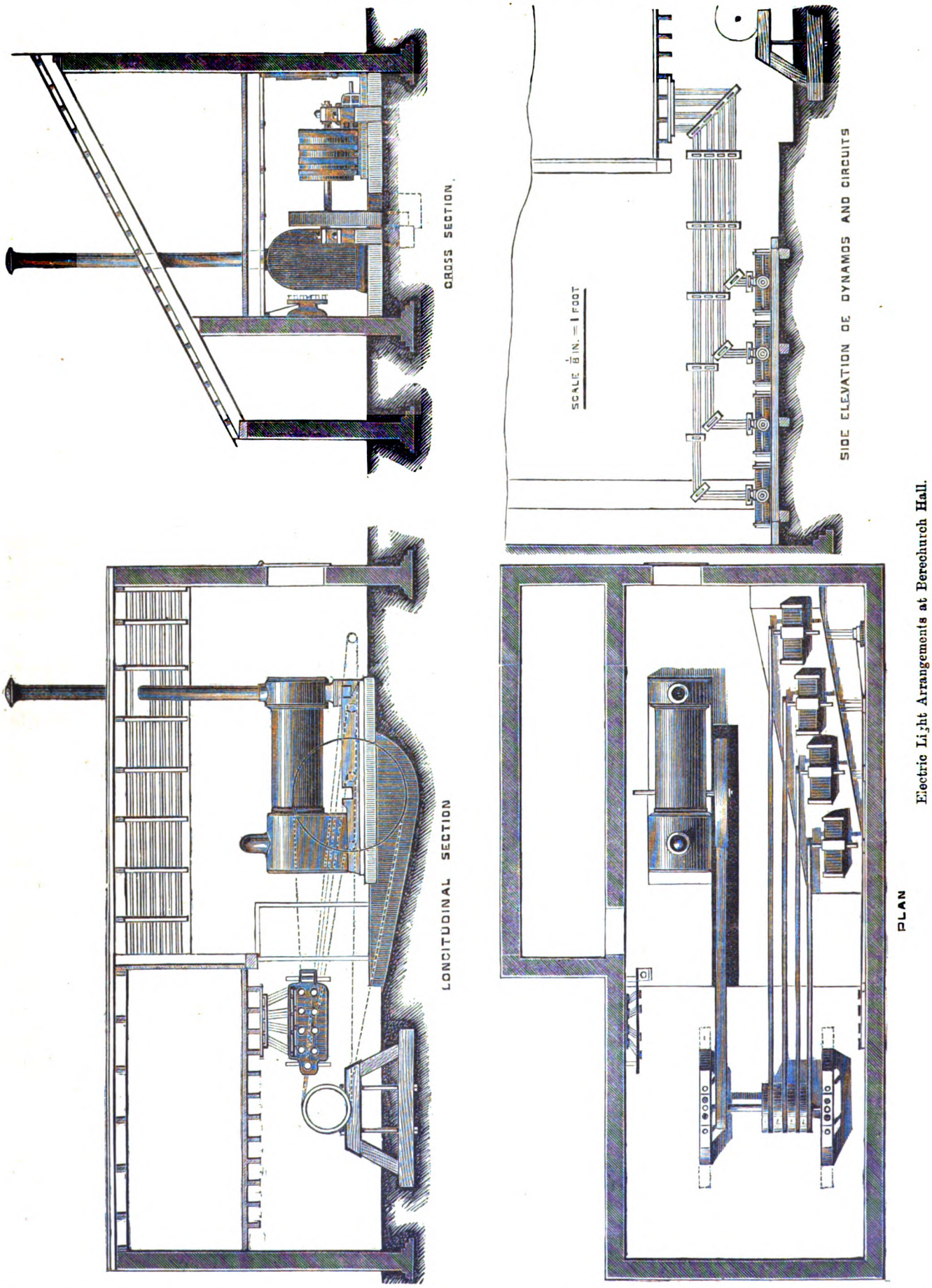
THE ELECTRIC LIGHT AT BERECHURCH HALL.



Electric Light Arrangements at Berechurch Hall.

When Mrs. Hemans wrote about "The Stately Homes of England" she had in view those old ancestral mansions which dot the landscape throughout the whole of rural England. However these mansions may lend themselves to poetic

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fancies, the realities of life necessitate the erection of other and newer residences. Age may give its charms, but science also plays its part, and lends itself to the increase of artistic beauty, lends itself, too, to the minimising of much that is detrimental to health and pleasure. The electric light has many advantages to commend it over candles, oil, or gas, and these must sooner or later cause its introduction into the mansions of the wealthy. One of the most, if not the most, complete installations in existence has just been made by Messrs. R. E. Crompton and Co., at Berechurch Hall, near Colchester. With the exception of two rooms, the Hall has been completely rebuilt by O. E. Coope, Esq., M.P., the foundations of the ancient building being chiefly followed. The two apartments retained are the large reception rooms in the east wing, the walls of which, however, have been refaced, and the windows remodelled. The new building is faced with red bricks and stone, and is of late 15th Century style, with mullioned windows, gables, dormers, tall chimneys, and square turrets. There is a plenitude of carving, of a refined and delicate character, and full of quaint conceits. The bay window of the drawing room is said to be the largest in Essex. The door at the main entrance reminds one of olden times. It is solidly constructed in oak, and studded with iron nails. There is an old-fashioned ingle-nooked fireplace in the entrance hall, which is 40ft. square. Altogether, the house is a lordly one, and every subsidiary arrangement is worthy of it. There are hydrants, for instance, at each end of the building, on every floor, for use in case of fire, and there is a lift for coals, luggage, and other heavy movables.

It was originally intended to light the hall by means of gas, to be manufactured on the premises, and during the building most of the gas pipes were laid throughout the house. Later on, and we think justly, it was decided to put aside gas for the electric light. The only illumination used, then, is obtained from electricity, and therefore the arrangements are of an eminently practical and permanent character. The work has, as we have said, been carried out by Messrs. R. E. Crompton and Co. The lamps used are Swan lamps. The current is obtained from a new design of Crompton-Bürgin machine, driven by a Davey-Paxman engine. In all there are 200 (59 volt) Swan lamps fitted up at Berechurch Hall, of which number 170 are in the house itself and 30 in outlying buildings, such as engine room and stables, servants' house, &c. Of the 170 lamps 28 are in the basement, 74 in the rooms on the ground floor, viz., the large hall, dining room, conservatory, billiard room, &c., and 68 lamps in the first and second floors, consisting mostly of bed rooms. The lamps are all placed in single parallel circuit and provided with switches, so that each single light (or, where there is a group of lights, each group) can be switched on or off at will.

As a general rule the switches are placed above 4ft. from the ground in the surface of the wall, close to the door. Lead cut-outs are provided, first, to each branch circuit, feeding one single lamp or group of lamps; secondly, to each circuit feeding one floor; and, thirdly, to each dynamo.

The size of the lead is, of course, proportional to the number of lamps in each instance.

All leads are embedded in the wall, and lead cut-out boxes and switch boxes are let into the wall flush with it.

The electric light fittings have been supplied by Messrs. R. W. Winfield and Co., of Birmingham; all wires are taken down to the lamps inside the fittings, so that nowhere can a wire be seen.

The current is brought to the house and returns from it by a pair of heavily insulated cables, 19 strand No. 12, laid underground in earthenware drain pipes, which are, of course, kept dry. The cables are taken by the well of the lift, and at each floor the branch circuit supplying that floor contains a heavy current switch and lead cut-out, so that each floor can be cut out from the main circuit—a convenient arrangement for testing.

The current is supplied by four Crompton-Bürgin compound dynamo machines, all driven off the same countershaft, and each capable of delivering a current of from 1 to 65 amperes at a constant electromotive force of 60 volts in the circuit. As all four dynamos are coupled parallel, a special arrangement of connections is necessary to prevent reversal of current and short-circuiting of one machine through the other.

It will suffice to describe one machine and its connections on the switch board. The lead from the positive brush is brought to a terminal on the switch board, which is connected to one side of a switch, the other side of which is connected to a terminal by means of a short piece of stout lead wire. From this second terminal the current is taken back to the machine and enters the coils of the field magnets. After passing through these it is taken along another lead to a third terminal on the switch board, from whence it is brought by a short copper wire to one contact plate of a two-way switch, the two opposite contact plates of which are connected, each to one of the two horizontal gun metal bars, seen in our illustration on the top of the switch board.

Electrical continuity is maintained between these bars through a dynamometer inserted into a line joining their right-hand ends, and the current is taken off at the left-hand end of the top bar. It will be seen that by putting the switch on to either one or the other of the top contact pieces, the current is made to either enter directly into the top bar, or first through the dynamometer and then into the top bar. In this way it is possible to measure the current given off by each machine separately, or the current of several machines together.

The current after leaving the top bar passes through a reversing switch into the main cable, which conveys it to the house. The return cable is coupled to the other terminal of the reversing switch, and the current is led from thence to the bottom bar on the switch board. This bar is coupled to a terminal, from which a lead goes direct to the negative brush. This arrangement is repeated for every dynamo, with the exception, however, of the three bars, dynamometer, and reversing switch, which are common to all. There is another bar on the switch board, viz., that connecting the centres of all the lower switches.

It will be seen that, by thus putting all the terminals of the field magnet coils into electrical connection, all machines must necessarily have similar fields, and a reversal of current in any one machine is impossible.

The shunt coils are coupled up in the usual way from brush to brush.

The reversing switch is used only occasionally, as it has been found to increase the life of incandescence lamps if the direction of current is occasionally changed.

It will be seen from our engraving that there are eight pulleys on the countershaft. Four of these are fast on it and in line with the pulleys on the dynamos, and four are loose pulleys. To stop any of the four machines it is merely necessary to open its switches on the board, and to shift the belt on to the loose pulley.

The belt now stands slightly at an angle, but as there is no movement (the loose pulley standing still) it will keep so. If it be desired to put that machine into motion, it suffices to close its switches, when the current, flowing back through the bobbin, makes it revolve, and, in doing so, shifts the belt on to the fast pulley. This is a very neat experiment, showing the transmission of power by the electric current.

The power is supplied, as we have said, by one of Messrs. Davey-Paxman's 12 h.-p. semi-portable engines, with engine under boiler, making 125 revolutions per minute. The corresponding speed of the dynamos is 1,500 revolutions. The dynamo machines are self-regulating, that is to say, they supply within the limits for which they are designed a current always proportional to the number of layers which happen to be switched on at the time. In other words, they keep the difference of potential throughout the circuit constant. That the machines are entirely self-regulating can best be seen from the fact that, if two are working and a third is suddenly switched in, no appreciable change in the lights occur. The engine room is lighted by five Swan lamps.

Throughout the house it has been as much as possible avoided to mass many lamps close together upon one electrolier, and a system of more divided arrangement has been

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adopted. Thus in the great hall, where it was originally intended to put three handsome pendants with seven gas lights each, nine single electric light pendants have been substituted. In no place are more than three lights grouped into one of the fittings, except the electrolier over the billiard table, where six lamps are used.

This system of distributing the lamps as much as possible is not only advisable on account of economising current, but also because the artistic effect is thereby much increased.

We propose to give further illustration of this installation next week, with an enlarged view of the switch board arrangements.

THE FERRANTI MACHINE.

The Ferranti machine has already obtained some notoriety, but it could not be said to be before the public till last Monday, when a large company was invited to witness its work. Before we describe the machine we may say that we can give no opinion as to its electrical efficiency. The facts from which to judge are not before us, and unless the facts are correct the conclusions will probably be wrong. In order to give an answer to the question whether a greater candle-power per horse-power can be obtained by using this machine than by using another machine requires not only a knowledge of the horse-power indicated by the engine, and the number of lamps running, but requires also that the lamps should be photometrically measured. It is easy to say a lamp gives x candles, it is difficult to prove without apparatus that it is at its normal candle-giving capacity. Eighteen candles instead of twenty in a hundred lamps means a diminution of two hundred candles. We merely state these things to show that any opinion expressed regarding this or any other machine, without experimental data, are not worth the paper they are written upon when employed to compare one machine with another.

The following paragraphs are taken from a pamphlet circulated on Monday evening:—

"The machine exhibited this evening is that producing an alternating current, and it is the joint invention of Sir William Thomson and Messrs. S. Ziani de Ferranti and Alfred Thompson.

"The attention of the makers is at the present moment being exclusively given to the production of this latter type of machine, in view of its suitability for running incandescent lights, and in consequence of the immense want existing at the present moment of a low tension machine, capable of running satisfactorily a large number of incandescent lamps.

"The machine, it will be noticed, is running 300 twenty candle-power "Swan" lamps, and careful tests show that this is being obtained by an expenditure of less than twenty-six horse-power, which includes the power absorbed by the small exciter."

We understood in the room that the machine was running 320 or 321 lamps, and not 300, as stated above. Of course, 320 would be a better result than 300.

Let us see the number of Swan lamps that could be obtained per horse-power, supposing all the power to be transmuted into electricity and given out in the lamp—an ideal state which many wish to obtain, but one hardly likely to be realised.

The A_1 Swan lamp gives 18 candles with an E.M.F. of 41 volts and a current of 1·46 ampere.

Thus the A_1 lamp absorbs

$$\frac{C \cdot E}{746} \text{ h.-p.} = \frac{1 \cdot 46 \times 41}{746} = \frac{59 \cdot 86}{746} = 12 \cdot 4.$$

It is impossible, if these figures are correct, to get 13 lamps per horse-power, and 12 lamps per horse-power is approaching perfection.

The B_1 Swan lamp gives 20 candles with an E.M.F. of 46 volts and a current of 1·32 ampere.

Thus the B_1 lamp absorbs

$$\frac{C \cdot E}{746} \text{ h.-p.} = \frac{1 \cdot 32 \times 46}{746} = \frac{60 \cdot 72}{746} = 12 \cdot 4 \text{ nearly,}$$

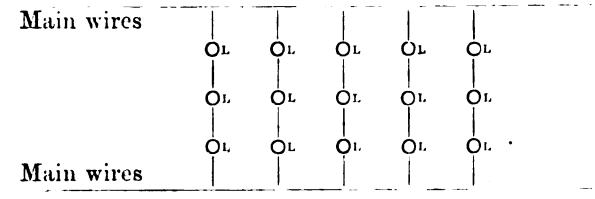
again showing—if the figures are correct—that only 12 lamps can be obtained under perfect conditions per horse-power.

We cannot, therefore, but think that some little error has been made in the claims above mentioned. We have not gone through the figures for the B, C, D, E, F, G, H, and I Swan lamps, which all are supposed to give 20 candles under certain conditions, but we should imagine that the maximum number of lamps per horse-power is about 12, and, therefore, candles per horse-power is about 240.

The figures given upon the wall at the experiments of Monday last were—

320 lamps,
160 amperes,
125 volts E.M.F.

The lamps were three in series, and each set of three in multiple arc, thus,



Taking 107 branches, that is $\frac{321}{3} = 107$, we get that the current through each branch, supposing resistances throughout exactly similar, $= \frac{160}{107} = 1 \cdot 49$ ampere, quite sufficient to keep the 41 volt lamps at their normal candle-power, but too much for the 46 volt lamps. Then, again, we should infer that 18 candle lamps were used, because the E.M.F. required for each branch is about $3 \times 41 = 123$ volts, whereas for the 20 candle lamp it is about $3 \times 46 = 138$ volts, in the former case the E.M.F. being about that of the machine as given, in the latter case somewhat higher. The difference between 18 and 20 candle-lamps taking 12 per horse-power is only 24 candles; but this is considerable when we are verging upon the confines of perfection.

Mathematicians have been so frequently laughed at by practical men that we are sorely tempted to cast aside our formula; but, perhaps, it will be better to wait a little, and to see if the startling results of 12 lamps of 20 candle-power are obtained in all ordinary installations. We are prepared to accept any facts, and believe nothing so probable as the unforeseen.

Turning now from the unknown to the known, we may say that this machine is one of the simplest we have ever seen. Those who noticed the machines of the White House Mills Company at the Crystal Palace last winter, and at the Paris Exhibition in the preceding autumn, will have some idea of a disc armature. It is essentially in its armature that the Ferranti machine differs from other alternate current machines. The field magnets are the usual electro-magnets, requiring an exciter. A small vertical Siemens was used at the exhibition on Monday. The armature, however, is the main point, and this we are particularly requested not to describe at present, because publication might interfere with foreign patents. There are, however, a few facts we may refer to which we venture to think will in no way invalidate any patent. It is well known that the armature is of copper strip, the total length of which in the machine exhibited is 120ft., the width 12·5mm., and the diameter 2mm.; weighing 18lb. 2oz. The resistance of the armature is stated as ·0265 ohm. It must necessarily be very low. The number of revolutions when running on Monday was 1,900 per minute, giving an E.M.F. of 125 volts. The general arrangement of the machine will be seen from

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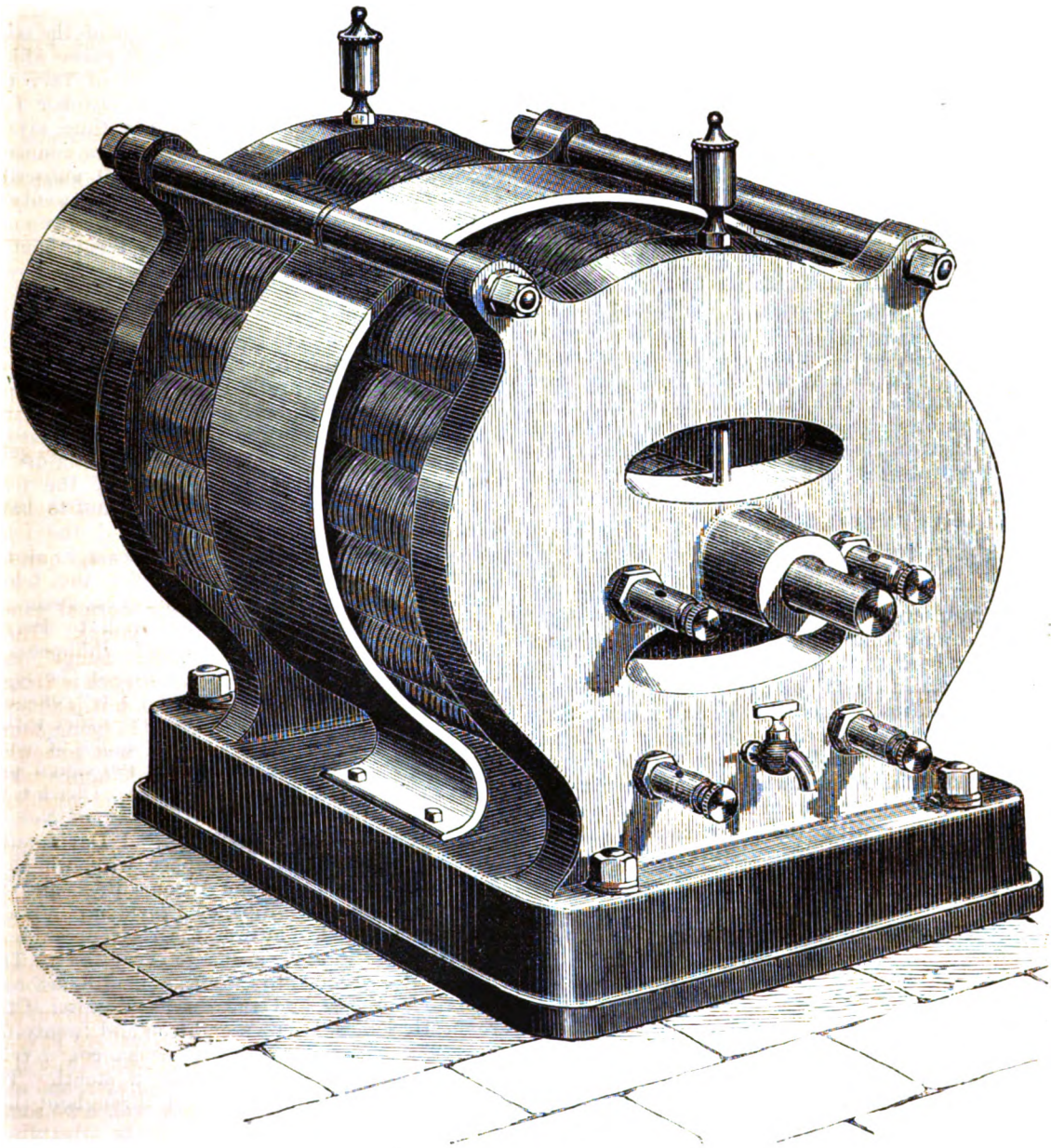
the illustration. The disc armature is hidden from sight by a brass ring. The field magnets are 32 in number, 16 on each side of the disc. Each core is surrounded by four coils of wire 3·5mm. diameter, and the coils are connected in series, the resistance being 2·5 ohms. The poles of the field magnets are arranged as in the Siemens alternate current machines. The current through the field magnet coils was 21·5 amperes, the exciter being, as we have already said, a small vertical Siemens machine, requiring about 1·7 h.-p.

The weight of the Ferranti machine compares very favourably with any other machine which we know, the one running weighing only about 11·75 cwt. The indicated horse-power of the engine when the machine was running the 300 or 320 lamps was under 27 h.-p.

We have already pointed out the difficulty in arriving at really valuable conclusions without having the whole of the required data. We may in the future have to modify our opinions regarding this machine considerably. Meanwhile we may say that, putting aside the exact electrical efficiency, it must necessarily attract considerable favour, because of its simplicity and small weight. The machine shown has, of course, the usual disadvantages of an alternate current machine. It cannot be used to transmit power, nor to charge secondary batteries, nor for electro-chemical work, and when the leads are very long and the branches numerous, the reversal of current a large number of turns per minute will have its effect, and, we imagine, will not increase the efficiency.

Since the first part of this description was in type we have learned that Mr. Swan has slightly improved his 18 and 20 candle-power lamp, so that 240 candles per horse-power could be obtained, providing the total power was converted into light in the lamp.

We hope to be able to illustrate the armature shortly.



The Ferranti Dynamo.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 24th November, 1882, were £2,713, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company (Limited).

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LITERATURE.

HYDROSTATICS.

Hydrostatics, or Theoretical Mechanics. Part II. By J. T. Bottomley, M.A., F.R.S.E. [William Collins, Sons, and Co.]

A few years ago Messrs. Collins, having in view the requirements of the Science Examinations at South Kensington, and seeing that at that time trustworthy books on science subjects were few, undertook the publication of two series of scientific books. The one series was intended for the use of students for the elementary stages of the Science Examinations, the other for the use of advanced students. Mr. Bottomley has written two books for the elementary series, of which the one before us is the second. It may be thought that "Hydrostatics" has little to do with electricity, but the contrary is the case. The analogies between the phenomena of perfect fluids and electricity are many, and most teachers of electricity appeal more or less to these analogies to assist them in explaining electrical phenomena. Further, there are many electricians who believe elecericity to be an entity, a something approximating to a perfect fluid. Hence, a knowledge of the laws appertaining to fluids is of great importance to electrical students. As an elementary book the student will find this generally accurate, concise, and clear. We would have a few alterations. Among others we may mention one or two trifling ones. South Kensington science students as a rule do not read Greek, and although they may guess Hiero's exclamation, and title of his work, p. 41, they will not recognise εὕρηκα. Why not put eureka in brackets, 'tis almost an English word, and so for the title. Again, if we have no international scientific agreements as to a central position to be taken by *all* authors for figures in text books about barometric pressure, attraction of gravitation, &c., surely London to an Englisman has claims over Glasgow, Edinburgh, or Paris. Is every author to give the figures for the town he lives in? If so, our elementary text books will soon give rise to anathemas. Our opinion upon this subject is very strong, and we would not introduce as a class book to our students any book that took as the central point any other than the recognised capital of the empire. We live in hopes that authors will see the necessity of an understanding of this kind, and that any difference of opinion may be put aside in order to benefit the whole student world. The writer of this notice is not afraid to acknowledge himself a student, though at the same time a teacher, and having had a somewhat lengthy experience with the examinations at the southern universities, he may be somewhat prejudiced in this matter.

ELECTRIC LIGHT ARITHMETIC.

Electric Light Arithmetic. By R. E. Day, M.A. [Macmillan and Co.]

This very useful little book contains a series of questions involving the ordinary electrical formulæ, many of the questions having solutions worked out, whilst others are left for the student to solve. It is well understood by those who have a knowledge of the requirements of electric lighting that the vast majority of practical questions involve little more mathematics than arithmetic and simple equations. Mr. Day commences with questions on resistance, then on current, then heating effect, work, and so on. We are not quite sure whether we agree with the haste to use the nomenclature suggested at Paris and Southampton. We are quite sure that we prefer other symbols than those Mr. Day has chosen. It only requires Jones, Brown, and Robinson to write a few papers upon electrical subjects, and then to propose a new nomenclature altogether for another change. This matter is, however, outside of Mr. Day's book. The mere choice of I or C to represent current, the introduction of watts, amperes, coulombs, detracts nothing from the intrinsic value of a series of arithmetical and algebraical questions. For these we are thankful to Mr. Day, and only regret, for the sake of the student, that the work is not double the size. The young electrical engineer cannot work too many of these simple problems. He must gain valuable experience by patiently working out these questions, and the more so as the figures given by Mr. Day are figures derived from practice—by these we mean that the questions are absolutely similar to those which arise in the everyday work of an electrical engineer.

THE GROWTH OF TELEPHONE BUSINESS IN AMERICA.

An illustration of the rapid growth of the telephone business generally is found in the increase which has taken place in Lowell, Mass. In the fall of 1877 the exchange was started with sixty subscribers. October 1, 1880, it had 600 subscribers, and at the present time, says the *Boston Globe*, there are about 900 subscribers connected with the exchange, showing an increase of 150 subscribers a year. The company is now putting in about twenty new instruments a month in Lowell alone, and the ratio of increase to the population is about the same throughout the territory covered by the consolidated exchanges. Lowell has one telephone to every sixty-two of its population, a very large proportion. In Portland, Me., there are 700 telephones, and the ratio is one to every fifty of population, the largest ratio in the world in any city of the same size. Considering, however, that there are in Lowell 20,000 mill operatives, the large number of telephones in use in that city is even more remarkable. One would naturally suppose that the increased use of the telephone, particularly for long-distance talking, would seriously affect the business of the telegraph companies. Oddly enough this appears not to have been the case. In Lowell, for instance, to-day the telephone company receives and sends as many messages as the Western Union Telegraph Company, and yet the telegraph company is doing half as large a business again as it was two years ago. The distance from Lowell to Portland is 115 miles, and, unless the atmospheric influences are exceptionally unfavourable, conversation can be readily carried on between these two points. The consolidated New England companies have a standing order with Washburn and Moen, of Worcester, for 300 miles of wire a month. They also have standing orders for 400 signal bells a month from Post and Co., of Cincinnati, Charles Williams, of Boston, the Western Electric Company, of New York, Gilliland and Co., of Indianapolis, and Davis and Watts, of Baltimore. The insulated copper wire, which is used for inside work, comes from the Ansonia Brass and Copper Company and Eugene Phillips, of Providence. The number of operators required to answer the calls of subscribers is, in Lowell, fifteen to 900, or one to every sixty. The operators are paid from 18dols. to 30dols. a month, according to their ability, experience, and the service required of them. They are mostly ladies, between eighteen and twenty-four years of age. The superintendents of exchanges receive salaries varying from 50dols. to 100dols. a month. These are the average salaries paid for the work throughout the country.

Electricity and Plants.—Mr. A. J. Kunkel finds that leaf veins are generally positive toward the rest of the leaf, but the direction of the current is reversed if the spot on the leaf where the electrode is placed is wetted before the other electrode is placed on the vein. A spot long moistened is positive toward one freshly wetted. When a plant is bent or wounded, the electrode near the bend or wound is negative to the other. Dr. J. Burdon Sanderson has noticed somewhat similar phenomena in the leaf of the Venus's fly trap (*Dionœa muscipula*), the under surface of the sensitive lobe of the leaf being electro-negative to the upper at the moment that the leaf is irritated; after about half a second the upper surface becomes electro-negative, and remains so for some time.

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THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

On Thursday evening, the 23rd ult., the president of this society, Lt.-Colonel C. E. WEBBER, R.E., read a paper describing the operations of the telegraphs with the expeditionary forces in the late Egyptian war. The first part of the paper was occupied with a retrospective account of the rise and progress of military telegraphy in this country, associated with which in a most distinguished manner was the name of Colonel Frank Bolton, the hon. secretary of the society. So long ago as 1855-7 he had written on the subject, and had submitted plans to the Government, which were investigated by an ordnance and select committee, of which Field-Marshal Burgoyne was a member. In 1862 Colonel Bolton also read a paper at Chatham, where portable apparatus of his construction was exhibited, which in the following year was adopted in the army, and shortly afterwards by the navy. Colonel Malcolm's labours in the same direction were also gracefully acknowledged, his division of the signalling under four heads—namely, permanent, semi-permanent, field, and visual, being fully described. The number-code, which, together with other recommendations then put forward, were adopted in 1876, was advocated by Colonel Webber himself in 1872. Differing from other military authorities on the matter of organisation he had subsequently read a paper before the United Service Institute recommending central control for the army telegraphs under one administration, and Col. Webber was understood to say that his experience in the late campaign had confirmed the views then enunciated. Turning to the immediate subject of the evening, Colonel Webber then described the actual condition of the Egyptian telegraphs when the expeditionary force arrived. They are modelled on the Indian lines, which in most particulars they closely resemble, the poles, however, being similar to those seen in Austria. The insulators are of Mr. Andrew's pattern, and are fixed to opposite sides of the poles, the wires being carried diagonally, as is the case in France, where cross arms are not in use. The battery is the Minotti, and the rule for power is 12 cells per 100 miles in dry weather, 18 cells for wet. The telegraphists were partly Europeans of various nationalities, but mostly Egyptians, seventy per cent. of whom could signal in no language but their own. Many of the former had fled for safety, and most of the latter had, of course, joined the enemy. The first business of the expedition was to restore the lines—many of which had been damaged and deserted—to the Egyptian Government, as also the system belonging to the Eastern Telegraph Company, which, being European property, had been singled out with special malice for destruction. This applied especially to the line between Cairo and Suez, *viâ* Zagazig and Ismailia. The work of restoration was done under very trying circumstances, and was rendered possible only by the devoted and cheerful service of the blue jackets, who, anywhere and everywhere, turned their hands to whatever was found them to do in a manner which provoked the warmest admiration. The laying of the cable between Alexandria and Port Said, the maintenance of the line between the last-named place and Ismailia were next referred to. Later on, the line terminating at Zagazig was extended to Kantara, and a military wire also between Belbeis and Cairo was erected.

But as the crisis of the campaign approached, the chief anxiety was for the wires connecting the basis of operations at Ismailia with the front—that is to say, with Kasassin. Between Kasassin and Tel-el-Kebir it is needless to say the wires had been destroyed; and pending the final attack, the Kasassin and Ismailia circuit was the one on which fell the main brunt of the traffic. The work was most trying and arduous for the operators, the heat intense, the traffic heavy, and the flies insufferable. As the wires were carried along the railroad, and the railroad, besides being the track for trains, was also the chief highway, the poles had continually to be repaired, inspection at least twice a day being needful all the time. Sometimes the telegraphists' position was evidently one of considerable danger, though Colonel Webber did not speak of it as such. They were soldiers, and facing danger is, of course, part of their duty; but it probably struck the audience that it is one thing to face danger in the field, and quite another to be shelled in a tent while you have to keep "pegging away," not with a rifle, but with a Morse key. "As an illustration of how one may realise the actualities of warfare at a distance by means of the telegraph"—so Colonel Webber put it—"I may mention that one night the operator at the other end stopped the signalling, saying, 'I must change instruments as I cannot read by sound any longer for the firing.' There was a pause for about five minutes; then a call. "What now?" we asked, to which the answer came 'the firing is getting closer, I will go out and see what is happening.' We waited some few minutes, and then were told that a shell had burst close to the tent." This interesting little episode was pursued no further, but it seems that the telegraphing went on all the same, occupied with messages, which from a military point of view took priority even over shells.

When the attack on Arabi's position took place the first thing to be done was to ascertain how were the wires southwards to Cario. Col. Webber himself made straight for the railway station at Kebir, and there found the office in the utmost confusion, the Egyptians having fled from it only ten minutes previously. Mr. Clarke, of the Intelligence Department, called up one or two stations, and it was at once fouud that the lines had not been broken; and in due course they were joined through. During the fifteen days which followed, some 5,000 telegrams were signalled through the military offices alone, many of which, being cypher messages, required the utmost care in despatch. Col Webber believed that they had been signalled with great accuracy, a circumstance which he attributed to the capital training the men had had in England in the postal telegraph service.

Mr. W. H. PREECE, F.R.S., who occupied the chair, offered some appropriate comments upon the paper, in the course of which he inquired how it was that Colonel Webber arrived at the Tel-el-Kebir Railway telegraph office alone, and had to enlist the assistance of a couple of Highlanders, fresh from—or rather wearied with—the heat and toil of battle to get the wires in order? Where was the C troop of Royal Engineers? Was it the fact that they were commanded by an officer who was not a telegraph man at all?

To these questions Colonel WEBBER replied that, like the ways of Providence, the ways of the War Office sometimes were inscrutable, and he confessed he could not give Mr. Preece a quite satisfactory answer.

A hearty vote of thanks, proposed by Mr. ANSELL and seconded by Mr. PATEY, concluded the proceedings.

BRUSH ELECTRIC LIGHT AND POWER COMPANY OF SCOTLAND (LIMITED).

An extraordinary general meeting of this Company was held last Tuesday at the New Exchange-buildings, George-yard, Lombard-street, under the presidency of the Earl of Crawford and Balcarres.

The SECRETARY (Mr. Fred. M. Brockelbank) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, you have met to-day in order to receive a statement from the Board as to certain proceedings which have taken place owing to a disclosure which was made in a letter by Sir Charles Bright, and to consider what would be the effect of certain actions which have been brought by some of the shareholders against the Company. Perhaps it would not be wrong if I were to say a few words to you first on the origin or history of this Company. In 1881, the Anglo-American Brush Corporation desired to push their business in Scotland, and therefore they entered into a certain contract with Mr. Hope to form a small company in Scotland to introduce their system, and later on they desired that he should form a larger company in order to work their patents on a more extended basis. Mr. Hope duly formed a company, which was called the Scottish Brush Electric Light and Power Company, and with his colleagues he then proceeded to lay the ground for the formation of this present Company, of which we are all members. Shortly before the formation of this present Company, two licenses were granted to the Scottish Brush Company from the Anglo-American Brush Corporation. Those licenses were dated the 14th of March, 1882, and I will, with your permission, refer to the items of those licenses more explicitly in a minute or two. Those licenses were handed over to the present Company on its incorporation, and they are referred to in its prospectus, and they are also scheduled in the contract. The prospectuses were issued, if I recollect right, on the 20th May, and the success in the applications for shares was a very remarkable one, I think I may say, inasmuch as though we had only 20,000 shares to allot, we had applications for 373,281 shares. The directors did all they could to work this allotment in as just and fair a manner as possible. I consider that the amount of labour which they spent on that object gave them very difficult work, and it was not a pleasant task, yet it was one which they did, and I think they did it conscientiously. The matters I wish now to draw your attention to are the questions of the licenses, those licenses which were handed over by the Anglo-American Brush Corporation on March 14 to the Scottish Brush Company. Having read the clauses relating to the granting of the Brush and the Lane-Fox licenses, he observed: Both these licenses, gentlemen, are in terms which may be considered exclusive licenses. I do not wish at the present moment to go into any question of argument as to the meaning of a word, but I can only say that the word was very carefully considered by the gentlemen who drew up the prospectus, in which they followed other companies. Other gentlemen had to draw up prospectuses, and they also believed the same thing—that by the license granted for the Lane-Fox patents we had the power of supplying Lane-Fox lamps for electric lighting, and that nobody else had that power of supplying the Lane-Fox lamps for electric lighting. Consequently this prospectus was issued by the gentlemen of the Board, who drew it up in all good faith, and they thereby believed that what they said was correct. Within a short time since, however, I am sorry to say a letter appeared, signed by Sir Charles Bright, and disclosing to us all that there had been a license granted to the British Electric Light Company previous to that which was granted to us. There is also with the license a covenant in a separate deed which was signed by the British Electric Light Company, agreeing that they would not in any manner use

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the Lane-Fox lamp in connection with their license. Therefore, so far as I apprehend, the British Electric Light Company are in possession of a patent, but are not in possession of any means of selling the Lane-Fox lamp to the public, or of saying in any way whatever that their position has anything to do with the Lane-Fox lamp. They are merely able to use the method, but they cannot sell the Lane-Fox lamp in Scotland or anywhere else. Gentlemen, when I saw this letter of Sir Charles Bright I could not help asking myself a question—why was this not said before? Why has the Brush Electric Light Company permitted this false statement that it is said we have made to pass unnoticed for so many months? I have never tried to give an answer, and I decline to give an answer. Well, now, gentlemen, the next matter I have to bring before you is to inform you that certain shareholders of the Company have taken action against the Company, requesting a return of their capital—a return of the amount of money laid out by them in subscribing for their shares. Well, now, there are certain questions raised by the litigation which I may summarise shortly if you will permit me. First of all, the question will arise—Is the statement in the prospectus a mis-statement of fact. Shareholders will doubtless say "Yes," as the license is said in the prospectus to be exclusive, and it is shown that there is another license in existence. For the Company, we may say that the prospectus was not a mis-statement, for although the British Electric Light Company have, as I have already mentioned, the mere license for the patents, it cannot sell the Lane-Fox lamp under such a name. It can sell an article; it can sell a piece of glass in which the air is exhausted, in which there are filaments of carbon, and in which the carbon is in a certain shape. Well, gentlemen, all incandescent lamps are in that shape. They are all made of glass; all have a filament of carbon, I may say; the air is exhausted, and the electric current is passed through the wire; it gets white hot, and it emits light. Some call them the Lane-Fox, some the Swan, others the Edison, but there is very little difference between them. I said the British Electric Light Company have this license, but they cannot sell a Lane-Fox lamp. Assuming, however, that what we have placed before you is a mis-statement, the question will arise—Is it a material mis-statement—one which would entitle a shareholder to set aside his contract to take shares? To this—though, as a matter of fact, it is held that the Lane-Fox patents are no longer of any great value—I do not like to express my own opinion whether it could be said to be a material mis-statement or not. Of course it would be open for a shareholder to say before the judge that it was the Lane-Fox lamp that induced him to subscribe for shares in this Company. I do not wish, gentlemen, to state any theory of my own. I am a layman, I am not accustomed to the translation of the laws of this country, but still there is that probability that a shareholder might say "I held by the Lane-Fox lamp; it is the Lane-Fox lamp which caused me to subscribe for shares, and though the Lane-Fox lamp is now worth nothing, I will still try to get my money back." Well, now, in the event, gentlemen, of this litigation proceeding, there are certain effects possible, certain effects probable, and certain effects certain to the Company. We have to do with an unknown quantity when we go to litigation. We are in presence of the great infinite; we are unable to say how the carriage of justice will proceed. Very often it appears perfectly certain to both sides that they are in the right, and yet the judge is obliged to say that one is wrong, and I am afraid that very likely we shall come to that, unless gentlemen should see that it would be to their good that all these actions should cease. The actions may be successful, but it is not easy to foretell this matter. There is always this element of uncertainty. There is, however, one question which is absolutely certain, and that is that this litigation must involve the Company in serious expense in defending itself. It must also hinder us from carrying on the work of the Company, because it is impossible that we could carry on to any great extent with liabilities hanging over us which cannot be estimated for a considerable period of time. If we assume that these actions are upheld against the Company, in all probability we could not recover the blow, and we should then have to go into liquidation, and what I consider a really flourishing business would be thrown away. Even should the actions against the Company fail, still there is the expense of litigation, which I am sure everybody is glad to be out of. Then what I consider to be as harmful to the Company as loss of money by litigation is the loss of time, the loss of opportunity of pushing our system—for how can we go forward in Scotland, how can we take contracts over a series of years, how can we even go before other gentlemen with the view of purchasing what we consider to be of very great advantage to the Company—that is, an incandescent system—how could we propose to ourselves to lay out money while we are in this position? I think really that should the shareholders to-day, after having heard what has been said, give us some means of feeling that it is our duty and in their interest to carry on the business of the Company, your Board would feel far more pleasure in carrying on their work, feeling that they had the confidence of the shareholders, and although they do their best at present, still they would endeavour to do their double best. I forgot, gentlemen, to mention that perhaps some of the shareholders present would like to know what has been done in Scotland, and what our future prospects are. Well, if you will permit me, I will call upon Mr. Dickson, who has been so kind as to take upon himself the managing directorship of this department, and has given it great time, deep consideration, and anxious thought, and I think from his intimate knowledge of Scotland, and the mercantile parts of Scotland, the interests of shareholders are well left in his hands

Mr. DICKSON stated that at the time the company was formed they were aware that, irrespective of the Lane-Fox lamp, which was not such a great *pièce de résistance*, they had the Anglo-American Company's dynamo, as to which he held that a better one did not exist. They were carrying on operations in four of the principal towns in Scotland—Edinburgh, Glasgow, Dundee, and Aberdeen. At Edinburgh he believed the railway company would become an excellent customer of the Company. They had the privilege of running their wires along the side of the railway, which obviated the necessity of breaking up the streets, &c. At the Waverley station there were 32 lights, and he had put up one on the top of Princes-street, which showed the Town Council what they could do. They had gone to work as economically as possible, and he thought they gave their light as cheaply as any one could do the work. They were running the preliminary lights in Dundee, where they were giving the greatest satisfaction. They had offers of various contracts, and if the business of the Company was proceeded with, he did not doubt they would have plenty of work to do. Replying to a question, he added that the present contracts did not entail a loss.

Mr. MUSGRAVE repeated that he had still the greatest confidence in the Company. He held that shareholders should at once put their feet down on the attacks which had been made on their directors, and on the different companies.

The CHAIRMAN, in reply to other questions, stated that the Hammond Company were pushing the Ferranti machine, which was altogether different from that of this Company. The words in their license were "full license." The license was granted by the Anglo-American Corporation to the Scottish Brush Company, from which this Company sprang.

Mr. WILKINSON, in answer to Mr. Cunningham, stated that intimation had been sent to the liquidator of the Scottish Brush Company that this Company did make certain claims with respect to the misrepresentation as to the use of the Lane-Fox lamp.

On the motion of Mr. WALTER DALRYMPLE, seconded by Mr. IONIDES, the following resolution was unanimously carried:—"That the meeting, having heard the statement of the chairman, expresses its confidence in the Board of Directors, requests them to carry on the business of the Company, and to oppose all hostile actions brought by shareholders against the Company."

The proceedings then terminated with a vote of thanks to the chairman and directors.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES Nov. 29.		BUSINESS DONE WEEK ENDING Nov. 29. Highest.		Lowest.	
Anglo-American	47¼,	48½	48¾		47	
Do. Preferred	77½,	78½	78¾		77¾	
Do. Deferred	17½,	18¼	17¾		17½	
Brazil Submarine	11¼,	11¾	11¾		11¼	
Cuba	9½,	10	9¾		9¾	
Do. Preference	16,	17	—		—	
Direct Spanish	7,	7½	7¼		7	
Do. Preference	16,	17	16¾		16	
Direct United States Cable	11,	11½	11½		11¼	
Eastern Telegraph	10¾,	10¾	10 13-16		10¾	
Do. 6 per Cent. Preference	12½,	13½	13¼		13¼	
Do. 5 per Cent. Debentures, 1899	103,	106	—		—	
Eastern Extension	11¾,	12¼	12 3-16		11¾	
German Union	10,	10½	—		—	
Globe Telegraph and Trust Company	6¾,	6¾	6¾		6¾	
Do. Preference	12¾,	12¾	12 13-16		12¾	
Great Northern	12½,	12½	12½		12½	
Indo-European	30,	31	—		—	
Mediterranean Extension	1½,	2	—		—	
Do. Preference	6,	7	6½		6½	
Reuter's	12½,	13	13		13	
Submarine	245,	255	—		—	
West India and Panama	1½,	1¾	1¾		1½	
Do. 1st Preference	7,	7½	—		—	
Western Brazilian	7½,	7¾	7¾		7¾	
West. Union 7 per Cent. 1st Mortgage	121,	124	—		—	
Do. 6 per Cent. Sterling Bonds	100,	103	102½		102½	

TELEPHONES.

Consol. Telephone and Maintenance	1,	1¼	1¼		1 1-16
Oriental	⅝,	¾	13-16		13-16
United Telephone	10½,	11	10¾		10¼

ELECTRIC LIGHT.

Anglo-American Brush	10¼,	10¾	11¼		10 13-16
Maxim-Weston	⅜,	½	9-16		7-16
Eastern Electric	2,	2¼	2¼		2

TRAFFIC RECEIPTS FOR OCTOBER, 1882.

COMPANIES.	Oct., 1882.	Oct., 1881.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,000	2,192	—	192
Direct Spanish Telegraph Company	2,079	2,063	16	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	29,925	31,164	—	1,23
Eastern Telegraph Company	58,173	48,872	9,301	—
Great Northern Telegraph Company	21,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

ELECTRICAL ENGINEER.—An important Electric Lighting Company are OPEN to ENGAGE the services of an ELECTRICAL ENGINEER. To a thoroughly qualified gentleman most liberal terms will be offered.—Address, with references and full particulars of past experience, to ENGINEER, care of J. BURBIDGE and Co., 62, Moorgate-street, E.C.

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SLIP

ELECTRIC LIGHT IN NEW ZEALAND.—Swan lamps are being successfully used in the reading room of Watson's Hotel, Dunedin.

ELECTRIC LIGHT IN HOTELS.—The great hall of Cannon-street Hotel will be lighted by the electric light from the commencement of the new year.

AN AMERICAN FAURE COMPANY.—The Faure Electric Storage and Light Company has been incorporated in New York with a capital of 2,000,000 dollars.

A CHEAP BATTERY.—It is stated that Dr. Brard has devised a cheap battery by turning to account the action of nitrates in igneous fusion on incandescent charcoal.

NEW COMPANY.—The Incandescent Electric Lighting Company has been formed with a capital of £250,000 in £1 shares. Mr. R. E. B. Crompton is one of the first subscribers.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1882, amounted to £54,098, and to £49,829 in the corresponding period of 1881.

STUDENTS OF ELECTRICITY IN GLASGOW.—The number of members of the Glasgow College of Science and Arts Classes is—in electricity 103, and in electrical engineering, 76.

THE JABLOCHKOFF COMPANY.—The Jablochkoff Electric Light and Power Company, has appointed the secretary (Mr. Francis R. Reeve) to be secretary and general manager to the company.

DIRECT SPANISH TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1882, amounted to £1,998, against £1,810 in the corresponding period of last year.

ELECTRIC LIGHTING OF A TOWN HALL.—The new Town Hall, West Brighton, which is to be opened on the 13th inst., will be lighted by Swan lamps. The work is being carried out by Mr. Magnus Volk, of Brighton.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of November, 1882, amounted to £32,591, and to £32,557 for the corresponding period of 1881, being an increase of £34.

DIVIDEND.—The directors of the Brazilian Submarine Telegraph Company have declared an interim dividend of 3s. per share, or 6 per cent. per annum, free of income-tax, for the quarter ended September 30 last, payable on the 23rd inst.

ELECTRICITY AND THE EVAPORATION OF FLUIDS.—Professor Freeman, of the Johns Hopkins University, of Baltimore, concludes, from a long series of experiments, that electricity is not demonstrably disengaged by the evaporation of fluids.

ELECTRIC LIGHT AT SALTLEY.—Messrs. Brown, Marshall, and Co.'s premises at Saltley, near Birmingham, are about to be lighted by Brush lamps. The work has been carried out by the Birmingham and Warwickshire Brush Electric Light Company.

THE MUNICH EXPERIMENTS.—We have received advanced proofs of an article in the forthcoming number of *La Lumière Electrique*, in which M. du Moncel treats the experiments by M. Marcel Deprez, at the Munich Exhibition, in a very exhaustive manner.

LIFE OF THE EDISON LAMP.—It has been stated recently that, out of 130 Edison lamps used to light a factory in the United Kingdom for some time past, only nine have broken since they were first put in, and that the remainder have been burning over 2,400 hours.

ROYAL SOCIETY.—The following paper was to have been read by Dr. A. Waller and Mr. A. de Watteville at the meeting of this Society on Thursday, viz.:—"On the Alterations of the Excitability of the Sensory Nerves of Man by the Passage of a Galvanic Current."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended the 30th of November are £1,160, as compared with £2,254 in the corresponding period of 1881. The August receipts, estimated at £4,374, realised £4,362.

THE TELEPHONE IN GERMANY.—It appears that the telephone exchanges in 18 German cities comprise no less than 3,788 different stations. The total length of telegraph lines utilised by the telephonic service is 540 miles, giving a length of single wire equal to 4,017 miles.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for November, 1882, amounted to £20,440; for the period from January to November, 1882, they were £223,720; for the corresponding months of 1881, £218,291; and for the same period of 1880, £219,922.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.—The annual general meeting of this society will be held at 8 p.m. on Thursday, the 14th inst. The following paper will be read:—"The Application and Extension of Telephonic Communication in Japan," by Thomas J. Larkin, member.

ELECTRIC LIGHTING AT ASHFORD (KENT).—The South Eastern Brush Electric Light Company will commence lighting the saw mills and joinery works of Mr. Draper Fowler, at Ashford, this week. Brush lamps will be used. This is the first time that Ashford has seen the electric light, so far as we know.

BRADFORD TECHNICAL EXHIBITION, 1882.—This exhibition, which was brought to a close last week, has been lighted since its commencement by the Yorkshire Brush Electric Light and Power Company of Leeds, who have been awarded a gold medal for their exhibit of electrical apparatus at the above place.

ELECTRIC LIGHTING AT BRIGHTON.—The Pavilion Committee of the Brighton Town Council have decided to light the ground floor of the Royal Pavilion with electricity. The first section of the work will comprise the fitting up of 600 Swan lamps. Mr. Magnus Volk, of Brighton, will carry out the installation.

ELECTRIC LIGHT AT JARROW.—Messrs. Palmer and Co., shipbuilders, of Jarrow, who have been lighting their works for some time past with Brush lamps, have now requested the Hammond Electric Light Company to put in a 40-light machine and more lamps. Previously they were employing a 16-light machine only.

CABLE REPAIRED.—The West India and Panama Telegraph Company have received advice of the repair, on 1st inst., of the cable between Jamaica and Ponce (Porto Rico). The Chord line, St. Croix-Trinidad, has also been repaired, so that the company are in direct communication with all their stations except Colon, Panama.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of November was 2,005, estimated to produce £1,800, against 2,334 messages, producing £2,439 in the corresponding month of last year. The traffic receipts for the month of August, estimated at £2,550, realised £2,595.

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To be Wound Up.—The Telephone Supply Company is to be voluntarily wound up, by resolution passed on the 13th November, and confirmed on the 30th of the same month. Creditors should send in their names and addresses, with particulars of their claims, to Mr. F. R. Grigg, 6, Lombard-street, E.C., the liquidator, before the 15th instant.

The Birth of the Secondary Battery.—In 1801 a Frenchman named J. N. Gautherot discovered that, when wires of platinum or silver had been used as the terminals of a battery for decomposing water containing some salts, they became capable of giving a current of their own for a short time, irrespective of the battery to which they were attached.

The Life of the Maxim Lamp.—As an addition to the figures regarding the life of the Maxim incandescent lamp, given in a recent note, we take the following slip from an American source:—"The ferry boat 'Jersey City,' belonging to the Pennsylvania Railroad, is lighted by the Maxim lights, and their record has been given as averaging 1,645 hours, and the lamps still burning."

Electric Lighting in Leeds.—We learn that the Yorkshire Brush Electric Light and Power Company, of 1, East-parade, Leeds, have secured a contract for the lighting up of the market place and principal streets of Dewsbury, Yorkshire, during the forthcoming Christmas holidays, and this Company is now putting down machines and erecting wires and lamps for running about 16 2,000 candle-power Brush arc lights.

The Ader Telephone in Belgium.—Messrs. Mourlon and Co., of Brussels, have erected Ader telephones in the offices of the chief officials of the Société Générale for aiding national industry, so that the heads of the various departments can communicate with one another. The same instruments are also to be erected in the large granite works at Quenast. We should think that our own quarry owners would find the telephone useful.

Electric Lighting in Sheffield.—The large premises of Mr. Davy, provision merchant, Fargate, Sheffield, have been lighted by 120 Swan incandescence lamps, which are fed by one of Siemens's W_2 alternate current machines. The local press, in commenting upon the installation, state that "Messrs. Tasker Sons and Company, by whom the whole of the arrangements have been carried out, are to be congratulated upon a success which has no parallel in this neighbourhood."

City and Guilds of London Institute.—Mr. C. W. Siemens, D.C.L., F.R.S., has consented to distribute the prizes and certificates gained by the successful candidates of the metropolitan centres at the recent technological examinations, as well as by the students of the City and Guilds of London Technical College, Finsbury, and of the City and Guilds of London Technical Art School, Kennington. The distribution will take place on Thursday evening, December 14, at seven o'clock, in Goldsmiths' Hall, Foster-lane, E.C.

Dynamos.—On Monday night Professor Sylvanus P. Thompson delivered the first of a course of three Cantor Lectures on this subject at the Society of Arts. The first lecture dealt with the history and classification of the dynamo, and was illustrated by diagrams. The second and third lectures, to be delivered on the 11th and 18th inst., will treat of the dynamo in practice, and the dynamo as a motor. We shall reprint these lectures, with illustrations, in the usual course on their appearance in the *Journal of the Society of Arts*.

Electric Lighting in London.—The Lambeth Vestry are going to devote a special meeting to the consideration of the electric light one month hence. The Fulham Board of Works have resolved "That the consent of the Board be not given to any application for a license under the Electric Lighting Act, 1882, unless the draft license, as proposed by the applicants, has been deposited at the offices of the Board at least fourteen days before the day appointed for the special meeting convened for the purpose of giving such consent."

Illness of the Postmaster-General.—At the request of Mrs. Fawcett, the Secretary of the Post Office has issued a notice conveying her grateful thanks for the expressions of sympathy which she has received from the postal and telegraph staff in different parts of the United Kingdom. It is impossible for her at present to individually acknowledge their kindness, but she is confident they will not doubt that she heartily appreciates it. At the time of our going to press Mr. Fawcett's condition, though still precarious, was more satisfactory.

Newcastle-on-Tyne.—Although the requisite notices had been issued, the Town Council on Wednesday, resolved, by a majority of 29 to 15, to abandon for the present the application to the Board of Trade for a provisional order authorising them to supply electricity for all public and private purposes within the area of the city and county of Newcastle. It was stated that Mr. Chamberlain was anxious to insert a clause in the order compelling the corporation to make a trial in some district of the electric light, and this proposal evoked much opposition.

The Edison Lamp on Board Ship.—The Edison system, as recently applied to the "Tarawera" steamer, belonging to the Union Company of New Zealand, was exhibited on board that ship in Greenock Harbour last week. The "Tarawera" has just been built by Messrs. Denny and Co., of Dumbarton, and is one of the first ships belonging to this side of the Atlantic which has been fitted with the Edison lamps. The lights, to the number of 150, are scattered about the ship, in the state rooms, saloons, shaft tunnel, &c. The current is supplied by an L dynamo, driven by a Brotherhood three-cylinder direct-acting engine. The usual Edison fittings, fusible plugs, &c., have been employed. We hope to be able to furnish our readers with a few more details of this work before long.

Electric Lighting in the City.—At the last meeting of the Court of Common Council, Mr. Felton (the Chairman of the Commissioners of Sewers) said he was not at the moment able to state the exact area now lighted electrically, but the length of thoroughfare lighted by the Brush Company was 1,648 yards, and by the Maxim-Weston Company 1,703 yards. The whole matter was now under the consideration of the Commissioners of Sewers, and he believed—it was only his opinion—but he believed it was the intention of the Commission to have the whole of the City lighted by the electric light. The subject would come before the Commission at its next meeting, and the question would be whether the Commission would allow the various companies to compete for the lighting, or whether the City would undertake the lighting itself.

Electrical Exhibition at Vienna.—This exhibition, which was to have been opened this year, but was postponed on account of the Munich Exhibition, will take place next year. It is intended to open it on the 1st August, 1883, and to close it on the following 31st October. It will be held in the same buildings as the 1873 Exhibition. Demands for space should be sent in before the 1st January next to the

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Organising Committee, Vienna. Exhibitors will have nothing to pay for space, nor for the power required for general lighting. The power required by an exhibitor for his own exhibit, however, will be supplied to him at the rate of 20 kreuzers per horse-power per hour. Apparatus exhibited and not patented in Austria-Hungary will be protected as if patented up to the end of 1883, and should be specially mentioned to the committee. There will be no rewards.

Strand District Board of Works.—An influential body of members of this board visited the works of Messrs. Verity and Sons, on Wednesday night, for the purpose of inspecting the Edison electric lighting installation on the premises of the above named firm, in King-street, Covent-garden. The display was a most brilliant and artistic one, Mr. Edison's incandescent lamp being shown to the utmost advantage in every conceivable situation and pattern. The electrolier manufactured by Messrs. Verity, and exhibited at the Crystal Palace, which we illustrated at the time in these pages, was far excelled in beauty of design and richness of material by some that were shown on this occasion. For every purpose of indoor lighting, whether appended to simple brackets or worked into the design of costly electroliers, the lamps were effective and agreeable. The deputation seemed highly satisfied with the installation.

Society of Arts.—Since the commencement of the present session the society's meeting room has been lighted by means of electricity. A Siemens dynamo is employed, driven by an eight-horse power Crossley gas engine. Nearly the whole cost of these was defrayed by subscriptions from a few past and present members of the society's council. The lamps used are those of Edison, and there are at present fifty of them in the room. The chandeliers now in use have been lent by Messrs. Verity, who are constructing chandeliers to be permanently fitted now that the number of lights to be used has been decided upon. Temporary fittings have been put up in the council room, and the result having been proved satisfactory, it is in contemplation to arrange for the lighting by electricity of this and other parts of the building. At first some difficulties were found in getting sufficient steadiness in the light, but these have now been overcome by Messrs. Crossley.

Leeds Town Council and Electric Lighting.—In answer to a recent letter from the town clerk of Leeds, asking whether, in the event of the Town Council applying for an order, a clause would be inserted therein compelling them to supply the electric light, and pointing out that such clause should be of a permissive, and not a compulsory character, Mr. Chamberlain replied that "The Board of Trade have no hesitation in saying that, in their opinion, it was the intention of Parliament that the schemes to be sanctioned by licenses or provisional orders under the Act should be *bonâ fide* schemes for definite undertakings, and not schemes containing general powers authorising a corporation or a company to light all or any portion of a town if, when, and as they might in their discretion think it desirable to do so. It would further, in their opinion, be clearly contrary to the intention of Parliament to sanction a scheme which merely enables the promoters to appropriate an area of supply to the exclusion of other applicants."

Electric Lighting in Chelsea.—On Tuesday the Chelsea Vestry considered the question of electric lighting as set forth in a lengthy report from their surveyor, Mr. G. H. Stayton, C.E. We shall allude to this report, a copy of which we have been favoured with, at greater length in our next issue. We may say here, however, that the vestry unanimously adopted the following recommendations with which Mr. Stayton concludes his report, viz.:—"1. That at present it is not desirable for the vestry to apply for a license or provisional order. 2. That it is not desirable to consent to any application for a license until the draft shall have been submitted to, and has received the approval of, the vestry. 3. That it is desirable to support the application of any company who may appear most likely to carry out the undertaking in a satisfactory manner, and who will agree to such of the suggested conditions as the Board of Trade may approve and that the Electric Lighting Committee and the surveyor be empowered to enter into the necessary negotiations for effecting that object. 4. That the solicitors be instructed to watch the progress of the applications for provisional orders, and to take all necessary steps to oppose the same until satisfactory conditions are obtained."

Thunderstorms at Great Heights.—Being desirous of examining the air at great heights in order to ascertain the proportion of ammonia present, as well as some facts as to atmospheric nitrification, Messrs. Muntz and Aubin recently examined the record of thunderstorms kept at the Pic du Midi observatory, some 9,590 feet above the level of the sea. Of the 184 thunderstorms observed from 1873 to 1882 they found that only 23 had been produced at a height above 7,700 feet (where the original station of Plantade is situated). In the latter the summit of the Pic was surrounded by clouds, whence the discharges came. It may be said in general that in the Pyrrenean region the violent electric phenomena of thunderstorms never exceed a height of 10,000 feet (3,000 metres), and that, consequently, the formation of nitrates under the influence of electricity is below this limit. Atmospheric nitrification seems to be chiefly produced in the zone between the sea level and the mean height of clouds. This absence of fine powders of nitrates, the authors also remark, certainly contributes to the remarkable transparence of the air in high regions, and shows that the plants on high mountains and the soil they have formed can only obtain their nitrogenised matter from the ammonia of the air.

Electric Lighting of Brunn Theatre.—During the last week in November several gentlemen interested in science visited Brünn for the purpose of examining into the details of the Edison system as in use there. Amongst the visitors have been the Scientific Society from Vienna and the Imperial Commission from the same city. The Commission were so satisfied with the light that they will introduce it into the new Imperial Opera House as well as the Burg Theatre in Vienna. The lighting of the grand dancing hall in the Emperor's castle was also talked of. Professor Columbo and Signor Buzzi, from Milan, also visited the theatre, with the object of inspecting the system of regulation employed, in order to introduce it into the Scala Theatre at Milan. The Professor, we believe, will use no less than 3,000 lights for the stage alone. In connection with the opening night, a correspondent sends us the following account of an amusing incident which occurred. He says: "Mr. Rau had a large 'bouquet' made, and fixed an Edison lamp in the centre, connected with two invisible wires, which ran from underneath the stage. It was then presented to one of the leading stars, and the moment she received it connection was made and the lamp burned. The applause was terrific. It brought the house down."

The Telephone throughout the World.—The Compagnie Internationale des Téléphones has just published some interesting statistics relating to the position of telephone exchanges throughout the world on the 1st October, 1882. The telephone is more freely used in America than

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elsewhere, for there no rates have to be paid to State or town authorities. New York has 4,060 subscribers; Chicago, 2,726; Cincinnati, 1,880; Boston, 12,325; San Francisco, 1,300, &c. Some of these figures refer to May. There are now in the United States more than 100,000 subscribers, and certain small towns, with population less than 1,000, yet have 30 to 50 telephonic subscribers; some even more. As regards the absolute number of subscribers, Paris comes third, after New York and Chicago; it had on October 1 no fewer than 2,422 subscribers, while London had only 1,600, Amsterdam 700, Stockholm 672, Vienna 600, Berlin 581, Brussels 450, Turin 410, Copenhagen 400, Mexico 300, St. Petersburg 145, and Alexandria 118. While the annual subscription is 600f. in Paris, 500f. in London, and 400f. in the provincial towns of France, it descends to 300f. and 200f. in Belgium, 135f. and 130f. in Italy, and only 120f. in Switzerland. If we calculate for each town the ratio which the subscribers to telephone exchanges bear to the total number of inhabitants, we find that small American towns are far ahead, for in many there is one telephone to every twenty inhabitants; in Chicago and in Zurich, the proportion is about one per 200; in New York, one per 500; in Brussels, one per 800; in Paris, about one per 1,000; in Berlin, one per 2,000; in London, one per 3,000; and in St. Petersburg, only one per 4,000

The Magnetic Storm in America.—The *Operator* gives an account of the storm which occurred on the 17th November, from which we make the following extracts:—"The storm centre seemed to be along the valley of the Mississippi, and at its greatest severity in those parts of the country north of the latitude of Washington. The only wires that could be used at all were those connected in metallic circuits. All the cables and wires that touched the ground were absolutely useless. . . . At Chicago the intensity of the currents appears to have been greatest. The switch-board of the Western Union office was on fire a dozen times during the forenoon, and half-a-dozen keys were fused by the current, the points burning up even when parted to their farthest limits. At noon but a single wire out of fifteen between Chicago and New York was in operation, and it was frequently interrupted. The disturbance was greatest on east and west lines. Washington and Baltimore offices succeeded in working with each other for a while by means of the earth currents, as did also Washington and Norfolk, Cincinnati and Columbus, and Cincinnati and St. Louis. The longest circuit operated by the earth currents alone was that between Bangor, Me., and North Sydney, Cape Breton, 700 miles long. . . . A singular phenomenon was witnessed at the office of the Domestic Telephone Company in Newark, N.J. From 10 o'clock in the morning up to noon the drops on the annunciators, which indicate that a subscriber wishes to use the telephone, kept falling by the dozen at a time. At times every drop on the board would fall at once; at other times a whole row would give away, and at others only a dozen or so. No sooner would they be restored to their proper position than drop, drop, drop would be again heard. The superintendent said that such phenomena have been known before, but he could recall no cases where they lasted for so long a time. In the Cleveland, Ohio, exchange as many as fifty indicators dropped at one time. Similar experiences were had in exchanges in other parts of the country. In Milwaukee the novel experiment was made of connecting an Edison incandescent lamp in the circuit of one of the telegraph wires affected by the earth currents. According to the Edison Company's agent at Milwaukee the lamp glowed with a light equal to about thirty candles. This, Mr. Edison says, would indicate a current such as would be produced by the expenditure of eight horse powers [Query.—Ed. *E.*]. Some faint idea of the enormous energy of the storm may be gathered from this experiment, for if there had been 10,000 wires, each would probably have exhibited the same effects, and yet there is reason to believe that but a small portion of the currents traversing the earth's crust is diverted to the wires."

Provisional Orders.—The following notices of intention to apply for provisional orders have been made public in addition to those given in a Note in our last issue:—The Metropolitan Brush Electric Light and Power Company have given further notices relating to the following Metropolitan parishes and districts:—St. Pancras, Islington, Greenwich, Lewisham, Hornsey, Highgate, Southgate, Tottenham, Edmonton, Leyton, Hampstead, Willesden, Hendon, Finchley, Wandsworth, Wimbledon, Newington, St. George-the-Martyr, St. Saviour's, City of London, Clerkenwell, St. Luke's, St. Olave, Bermondsey, Rotherhithe, Hackney, Bethnal Green, Shoreditch, Fulham, Chiswick, Acton, Ealing, West and East Ham, and Wanstead.—The Edison Electric Light Company have given a general notice as regards the City and districts of London.—The Swan United Electric Light Company have given notices for Victoria district, South Kensington district, Hanover-square district, and the Strand district.—The Pilsen-Joel and General Electric Light Company have given notices, including Holborn, St. Giles's (Bloomsbury), St. Pancras, and the City of London.—The Incandescent Electric Lighting Company have given notices for Redditch, Birmingham, Northfield (Worcestershire), Reading (Berks.), and Walsall (Staffs.).—The Union Electric Light Company have given notices as to Brighton and Sheffield.—The South Staffordshire Electric Light Company have given notices relating to Walsall, Balsall Heath, Saltley, and Aston (all three suburbs of Birmingham), West Bromwich, Wednesbury, Darlaston, Wolverhampton, and Dudley.—The Lancashire and Yorkshire Electric Lighting Company, of 5, St. James's-square, Manchester, have filed notices including Stalybridge (Yorks.), Wakefield, and Hyde (Cheshire).—The Great Western Electric Light and Power Company have given notices as to Newport (Mon.), Gloucester, Cardiff, and Cheltenham.—A notice as to Sunderland has been registered by the North Eastern Electric Light and Power Company, of 61, John-street, Sunderland. Similar notices have also been given by the following corporations, in addition to those previously recorded by us, viz.:—Wigan, Stockton, Southport (Lancs.), Stockport (Cheshire and Lancs.), Bradford, Leamington, Bootle-cum-Linacre (near Liverpool), Burton-on-Trent, Blackpool (Lancs.), Sheffield, Accrington (Lancs.), Oldham, Batley (Yorks.), Liverpool, Chichester, Bolton, Birkenhead, Colchester, Preston (Lancs.), Reading, Nottingham, Brighton, Plymouth, Keighley (Yorks.), Manchester, Truro (Cornwall), Newcastle-on-Tyne, Leeds, Swansea, St. Helen's (Lancs.), Norwich, Portsmouth, Dover, Bath.—The following local authorities have filed notices as regards their own districts, viz.:—Beckenham (Kent), Nelson, Farnworth, Barton, Eccles, Winton and Monton, and Todmorden (all in Lancs.), East Stonehouse (Devon), Richmond (Surrey), Birkdale (Lancs.), Cambridge, Ealing (Middlesex), Altrincham (Cheshire), West Hartlepool, Chadderton (Lancs.), Weston-super-Mare, St. Pancras (London, N.), Buxton (Derbyshire), Ulverston (Lancs.), Aspull (Lancs.), and Hucknall Torkard (Notts.).

The Commissioners of Sewers and Electric Lighting.—At a meeting of the Commissioners of Sewers, held at the Guildhall on Tuesday last, Mr. Moore moved, "That the

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following resolutions passed at the special Court on November 21st last in regard to electric lighting, viz., 'That, whilst the Commission is now in favour of electric lighting in the abstract, it is advisable to allow all further experiments to be conducted at the risk of the lighting companies, and not at the expense of the ratepayers. That the Remembrancer be instructed to appear on the applications of the electric lighting companies, and secure clauses protecting public and private rights,' be, and the same are hereby, rescinded." Mr. Moore followed up his resolution by some remarks, from which we extract the following:—He said, "There were three courses open to them. The first was to obtain a provisional order. The effect of their proceedings at the last Court was to destroy the possibility of their obtaining a provisional order, but they could adopt the second method, which was to proceed by license. A provisional order was for 21 years; a license was only for seven years; but having a license it was possible for them to apply for a provisional order. At the last meeting alarming representations were made as to the heavy liabilities and costs they were likely to incur. They could see the worst of it from the results of the experiments into which the Commissioners had hitherto gone. They had it on the authority of the engineer that the actual cost of lighting the three districts they had hitherto experimented upon was £8,060. Of that £3,670 was the cost of works. Instead, therefore, of getting into half a million, or three millions, as was suggested, they could form an idea what the outside cost of the works would be in the event of the Commission seeking to extend them still further through the City. The actual cost of the light for twelve months over the area stated, calculating the cost of the plant, was £4,390, and the quantity of light which the public had received for that sum of money was 103,000 candles. The total illuminating power of gas over the same district was 6,000 odd candles, that was to say, they had sixteen times the amount of light for this district. The cost of electricity was £4,390, the cost of gas for the same district was £2,002. They had had sixteen times the amount of light, and had paid twice the cost of gas. He had consulted several eminent electricians, and all considered that the lighting of the City by electricity was most feasible and practicable. He, therefore, hoped they would, without hesitation, agree to his motion to rescind." The motion was duly seconded, and thereupon ensued one of those lively discussions, which are very amusing reading, but somewhat too full of "exuberant verbosity" for reproduction here. Suffice it to say that the motion was carried by 31 to 23, or a majority of 8; it was then found, however, that the number of members present was not sufficient to rescind the resolutions passed at the previous meetings, and an uproar at once arose, in the midst of which the chairman vacated his chair and the room. In the end the clerk was requisitioned to call a special meeting to consider the matter.

Electric Lighting.—Deputation to Mr. Chamberlain.—On Tuesday last a deputation representing the important corporations of England and Scotland had an interview with Mr. Chamberlain at the Board of Trade to urge upon him the importance of making the use of the electric light permissive, and not obligatory. Mr. Arnold Morley, M.P., introduced the deputation.—Mr. Littler, Q.C., stated the views of the deputation. He said the corporations did not take their action from any spirit of hostility to the introduction of the electric light, but they thought that on the principle of local self-government they should be allowed to exercise a discretion. The corporations were not desirous of admitting the companies otherwise than as their agents. The corporations were not averse to the electric light, as had been suggested in some of the public prints, but they wanted a discretion in the matter. Their constituents objected to having to spend large sums of money or else be regarded as defaulting. —Mr. Chamberlain, in reply, said he would take that opportunity of dispelling some misapprehension as to the action of the Board of Trade in this matter of electric lighting. At the same time he would not express any definite conclusion on the points raised until he had had further time to consider them. Mr. Chamberlain quoted certain sub-sections of the Act, and said that there were other proofs which to his mind showed that Parliament intended that no obstacles should be placed in the way of a full development of electrical operations, and he did not think that that object would be attained if it were placed in the power of a local authority, not only at the present moment but for a time during which great improvements might be made in these sciences, to keep out all other and possible competitors without undertaking at the same time to do anything themselves. What Parliament felt was this—that in the case of electricity there was a great danger that corporations and local authorities, through a desire to spare the ratepayers, would be disposed to delay experiments which might be necessary. Parliament, therefore, he thought, did intend that such a condition should be laid down by the Board of Trade as would prevent that evil; and it endeavoured to guard against the danger by the imperative conditions which it had attached to the granting of provisional orders and licenses, and he confessed the alarm which had been expressed in some quarters as to the possible intrusion of companies into their district seemed to him to be altogether exaggerated. With regard to the conditions under which alone these companies could be intruded, he was disposed to attach all possible weight to what Mr. Littler had said as to the uncertain condition of the whole subject at the present time. He did not see how the Board of Trade could make any distinction between corporations and companies in reference to provisional orders containing specific information as to the area of supply, as to the nature of the works, as to the amount of capital to be expended, &c. If the Board of Trade granted anything like the freedom which was asked for by corporations to companies, the evil would be very great in the case of those corporations which did not ask to supply themselves, but which were willing that the Act should be carried out by companies in their district. It was certainly their intention not to proceed without hearing everything that could possibly be said on all sides of the question. If an application were made by the company the Board of Trade would hear everything that the corporation had to urge against the grant to the company, even though the corporation stated that it was not itself prepared to enter upon the new field of supply; in fact, they would hear any general objections to a company going into the district, and no license would be granted until all the representations of the local authority had been heard against it. The policy of allowing companies to occupy a district (with the safeguards taken) was perfectly legitimate; and it was impossible for them to obtain more than a fair and reasonable profit. Then as to the breaking up of the streets, there was an express provision in the Act which would enable corporations to insist upon the insertion of a clause in the provisional order giving the corporation the power of breaking up the streets for, and at the expense of, the private undertakers who might undertake the supply of electricity.—Mr. Arnold Morley having thanked the right hon. gentleman, the deputation then withdrew.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XXI.

We ought now, perhaps, to enter on the ring type of armature devised by Pacinotti, and applied in the Gramme and a host of other machines; but a general understanding of the first principles involved in it is, we believe, pretty widely spread, and as a quantity of very interesting matter is pressing to be discussed, the complete investigation of the principles of the Gramme armature may be left over for a time.

What we shall now proceed to discuss is the action of a dynamo considered as a self-exciting machine.

We know how the E.M.F. is generated in the armature when it revolves in a magnetic field, and the data necessary to be given in order to calculate its amount; we have now to consider how the magnetic field is produced by means of a portion of this same E.M.F., and on what the efficiency of a dynamo as a current producer depends.

Now, there are two well-known methods of exciting the field magnets of a dynamo: the first is to send the whole current round them as well as through the external circuit, which is the ordinary or direct-current method; and the other is to send only a fraction of the whole current round the field magnets, but to apply to them the same E.M.F. (instead of the same current) as is applied to the external circuit; this method being known as the divided circuit or shunt method.

A dynamo excited according to the first plan is called an ordinary or *series dynamo*. Excited according to the second plan, it is called a *shunt dynamo*.

The theory of the latter is in some respects the more simple, and in many respects the more satisfactory; moreover, shunt-excitation is believed by many persons (the writer included) to be a better and more economical mode of working than excitation by total current. We will discuss it first.

Theory of the Shunt-dynamo.

We shall use the alphabet in the following sense, without regard to the meanings hitherto attached to the letters in these articles:—

a shall stand for the resistance of the armature wire from brush to brush, in ohms;

A for the current flowing through the armature wire, in amperes;

b shall be the resistance of the field magnet wire;

B the current passing through it;

r is to be a resistance equivalent to the external circuit, whether this consists of a simple wire or not;

C is the current in the external circuit;

E is to mean the total E.M.F. generated by the revolution of the armature, in volts;

e the E.M.F. applied to the external circuit, or the difference of potential between the terminals of the machines.

The only explanation needful concerning these symbols is with reference to r. In many cases the term "resistance" is not properly and simply applicable to the external circuit at all, as, for instance, if it contain secondary batteries or arc lamps; only when the circuit contains nothing but simple wires, incandescent lamps, or other such metallic conductors can the term resistance be directly and correctly applied. But, nevertheless, the ratio of $\frac{e}{C}$ has a certain definite value at every instant, though often its value is very fluctuating (notably so in the case of an arc lamp, where the *product* eC is, or should be, much more nearly constant than the *ratio*), and it is highly convenient to be able to speak of this ratio as the external resistance r. The meaning of r in every case is, therefore, accurately and completely defined as $\frac{e}{C}$.

This being premised, how many relations does Ohm's law give us among the above quantities? These:

$$e = r\,C \quad . \quad . \quad . \quad . \quad \text{(i)}$$
$$e = b\,B \quad . \quad . \quad . \quad . \quad \text{(ii)}$$
$$E - e = a\,A \quad . \quad . \quad . \quad . \quad \text{(iii)}$$

and common sense gives us one more, viz.:

$$A = B + C \quad \ldots\ldots \quad \text{(iv)}$$

What does Joule's law tell us about the heating of the different circuits? The following:—(a watt being $\frac{1}{746}$th of a horse-power)

Power expended in heating armature $= a\,A^2$ watts (v.)
Power expended in heating field magnet $= b\,B^2$ „ (vi.)
Power expended in external current $= r\,C^2$ „ (vii.)

The last of these is the useful power, the two former are the waste.

The electric *efficiency* of the shunt-dynamo is therefore—

$$\frac{\text{useful power}}{\text{total power}} = \frac{r\,C^2}{a\,A^2 + b\,B^2 + r\,C^2} \quad . \quad . \quad . \quad \text{(viii.)}$$

I call it the *electric* efficiency, because we do not here consider the *mechanical* waste of power in heating the bearings or the strap, but simply and solely the ratio of the power obtained as current in the external circuit to the total power obtained as current altogether. Observe that we are reckoning *the whole* of eC or rC^2 as useful power, although in practice part of r will consist of leading wires in which some waste heat will be produced. But it is obviously undesirable to heat your leading wires; and either they may be so thick that the heating is inappreciable, or else they may be as thick as is consistent with economy of capital, and the waste in them after that may be considered so far unavoidable as to be, to all intents and purposes, part of the useful effect.

When we come to the subject of the transmission of power, the resistance of the leading wires will be of extreme importance, and then we will fully take them into account.

The useful power and the total power are two things of such vital importance that we will introduce symbols for them, and will write their values in a variety of equivalent ways. The first call p, the second P, so that the ratio $\frac{p}{P}$ is the efficiency.

$$p = e\,C = r\,C^2 = \frac{e^2}{r} \quad . \quad . \quad . \quad . \quad . \quad \text{(ix.)}$$

$$P = E\,A = e\,A + a\,A^2 = e\,(B + C) + a\,(B + C)^2$$
$$= b\,B^2 + r\,C^2 + a\,(B + C)^2 \quad . \quad . \quad . \quad \text{(x.)}$$

The expression for the efficiency given in equation (viii) is by no means in its simplest form, and we will proceed to simplify it by help of equation (i) and (ii) combined. Referring to (i) and (ii) we perceive that they give us the simple, but very useful, fact that

$$\frac{B}{C} = \frac{r}{b} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(xi)}$$

and if we substitute this value of B in (viii), remembering also (iv), the currents all cancel, leaving only resistances, thus—

$$\text{Efficiency} = \frac{p}{P} = \frac{r\,b^2}{a\,(b + r)^2 + b\,r^2 + r b^2} \quad . \quad \text{(xii.)}$$

A still simpler thing to work with, than this ratio of the useful power to the total, is the ratio of the waste power to the useful; and this I shall call the *waste-ratio* of the dynamo. Its value is

$$\text{waste ratio} = \frac{\text{waste}}{\text{useful}} = \frac{a\,(b + r)^2 + b\,r^2}{r\,b^2}$$
$$= \frac{a}{r}\left(1 + \frac{r}{b}\right) + \frac{r}{b} \quad . \quad \text{(xiii.)}$$

This is an exceedingly simple and handy expression for a quantity which it is desirable to get as small as possible. If we determine the conditions necessary to make this a minimum it will be obviously the same thing as finding what will make the efficiency a maximum.

Problem 1.—For a given shunt-dynamo, what is the most economical value of the external resistance? In other words, through what external resistance shall we get the greatest effect? And what is, then, the maximum efficiency?

Ans.—By simply differentiating (xiii.) with respect to r, the best value of the external resistance is found to be

$$r = b\sqrt{\frac{a}{a + b}} \quad . \quad . \quad . \quad . \quad \text{(xiv.)}$$

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This is the formula given by Sir Wm. Thomson at the York meeting of the Brit. Assoc.

Inserting this value of r in (xiii.) and in (xi.) we get: the least possible waste ratio for the given dynamo

$$= \frac{2a}{b}\left\{1 + \sqrt{\left(1 + \frac{b}{a}\right)}\right\} \quad . \quad . \quad . \quad \text{(xv.)};$$

or the greatest possible efficiency of the given dynamo

$$= \frac{b}{2a + b + 2\sqrt{a}\sqrt{(a+b)}} \quad . \quad . \quad \text{(xvi.)}.$$

PROBLEM 2.—In constructing a dynamo, what is the most economical relation between the resistances of its field magnet wire and its armature?

Ans. By simple inspection of (xii.), or (xiii)., or (xv.), or (xvi.), the efficiency is seen to increase as the ratio $\frac{b}{a}$ increases, and to have no maximum; hence the greater the quantity of wire wound on the field magnets and the thicker the wire on the armature the better for economy. It would be very wasteful to have b only five or six times a; if b is as much as 400 times a there will be very little waste, but there will be still less if b is, say, 4,000 times a.

Assuming, therefore, that the given dynamo has as large a ratio $\frac{b}{a}$ as it ought to have, the equations xiv. and xvi. can be written in approximate, but quite sufficiently accurate, and very easily applied, forms thus:

$$\text{best value of } r = \sqrt{a\,(b-a)}. \quad . \quad . \quad \text{(xvii.)};$$

maximum efficiency corresponding

$$= 1 - 2\sqrt{\frac{a}{b}} + 2\frac{a}{b} \quad . \quad \text{(xviii.)}.$$

THE ELEMENTARY PRINCIPLES OF ELECTRICITY.

III.

DEF.—A surface is said to be *level* when a heavy body has no tendency to pass from any one point to any other upon the surface.

A horizontal plane is, practically, a level surface if its dimensions are small. Over an extended area a level surface conforms to the general form of the earth. Thus a complete level surface, drawn through any point, is approximately a spheroid whose centre is coincident with that of the earth.

The test practically employed in order to determine whether a surface is level or not consists in observing whether a mobile liquid has any tendency to flow from one point to another of the surface. For this purpose a spirit level is employed. A spirit level consists of a glass tube very slightly curved, and mounted with its convexity upwards. The tube is nearly filled with spirit, leaving only a small bubble. The bubble always occupies the highest point of the tube, that is, the centre of the bubble lies at that point of the tube where the tangent is horizontal. If the instrument is properly mounted the centre of the bubble will coincide with the middle of the tube, however the instrument may be turned in azimuth, so long as it lies on a horizontal plane; but if the level is placed on a plane which is not horizontal, the spirit will flow towards the lower end of the instrument, and the bubble occupy the highest portion. Thus the tendency of a heavy fluid to pass from points at a higher level to those at a lower level is practically utilised to test whether or not a surface is a *level* surface.

Spirit levels, as employed by carpenters, builders, &c., determine whether small plane surfaces are horizontal. As employed in the survey of a large tract of country the spirit level enables the surveyor to follow a curved surface which coincides with what would be the surface of still water—if water were present—but which cannot be regarded as a plane surface except over a very small area, and then only approximately so.

If a vertical straight line were erected in London, and points marked off upon the line at successive distances of one foot, and if level surfaces were drawn through these points their form would agree generally with the surface of the ocean supposed smooth, and they would cut the more elevated portion of the earth's surface in *contour* lines. But though the vertical distance between successive surfaces in London was exactly one foot, it would be found that the distance did not remain the same in other latitudes. At the poles it would be less than one foot, and at the equator more than one foot, just as the earth's polar radius is less than the radius through London, while the equatorial radius is greater.

The law by which the distances between successive surfaces would be regulated is the following:—*The work done on a given portion of matter in falling from any surface to the next would be the same at all points, and therefore equal to that done in falling between the same two surfaces in London.*

Hence, where gravity is strong, as at the poles, the distance between the successive surfaces will be small, but when gravity is weak, as at the equator, the distance will be proportionally great. As we recede from the earth's surface, these local differences will diminish, and the general form of the surfaces will approach more nearly to that of a sphere.

If we define a foot-pound as the work done by gravity on a pound in falling vertically through one foot to the sea level (Trinity high-water mark) in the latitude of London, thus making it an absolutely constant unit of work, instead of a variable unit as it is generally defined to be, then the work done on a pound in falling from one of our hypothetical level surfaces to the next will be everywhere a foot-pound, provided the surface to which the pound falls be that which passes through the Trinity high-water mark in London.

But if the distance between successive surfaces in London be in all cases a foot, the work done on a pound in falling from one surface to the next will diminish as we ascend, in consequence of the diminution of gravity. We may, however, so regulate the distances between successive surfaces in London that the work done may, in all cases, be a foot-pound. The distance between successive surfaces will then increase as the intensity of gravity diminishes with increased altitude, but the system of surfaces will possess the simple property that a foot-pound of work will be done on a pound in falling from each surface to the next in succession, whatever be the locality in which the fall takes place, and whatever be the elevation above the sea.

These surfaces may be numbered consecutively from the sea level, which may be regarded as zero. Surfaces below the sea level may have negative numbers assigned to them. The level of a point lying on one of these surfaces will then be represented by the number assigned to the surface, and the level of a point lying between consecutive surfaces will be represented by a fractional quantity. On this system the level of a point is represented by the number of foot-pounds of work done on a pound in falling from the point to the sea level, that is the surface whose level is zero. Levels thus determined may be said to be measured with the *foot-pound rule*. They differ from levels measured with the *foot rule* on account of the variation of gravity. On the foot-pound system the difference of level between two points is equal to the number of foot-pounds of work done by gravity on a pound in falling from the first point to the second, whether the points lie in the same vertical or not.

It should be noticed that the *foot-pound* as above employed is not the foot-pound as ordinarily defined, but is a constant unit not varying with the intensity of gravity in different localities. We might have drawn our surfaces so that the work done on a gramme in descending from each surface to the next was always equal to one erg, and the set of surfaces would then have corresponded to the C.-G.-S. absolute system of units.

If it is desired to measure the depth of a mine for the purpose of estimating the cost of pumping water from it, or the height of a mountain lake, for the purpose of estimating its value as a source of power, it is clear that the intensity of gravity ought to be taken into account, and thus it is the *foot-pound rule* and not the *foot rule* which ought, theoretically, to be employed in the measurement.

A method (which is practically possible) of employing the foot-pound rule for the measurement of the difference

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of level between two points is the following:—Connect the two points by a tube filled with water, and attach a pressure gauge, which registers in *absolute* measure, to the lower end of the tube. The registration of the gauge will indicate the difference of level between the ends of the tube on the *foot-pound* system.

Henry Cavendish pointed out that electricity, in many of its properties, resembles an incompressible fluid, so that there are many analogies between the behaviour of electricity in conductors and of water in tubes or other vessels.

If a heavy fluid tend to pass from a point A to a point B, then A is said to be at a higher level than B. If positive electricity tend to pass from one point to another, the first is said to be at a higher *potential* (or electric level) than the second.

The electric *potential* is in the theory of electricity what level is in the theory of gravitation.

Def. The *potential* of a conductor is its electric condition with reference to its power of communicating electricity to, or of receiving electricity from, other conductors.

As thus stated, the definition of electric potential is similar to that of temperature in the theory of heat. But, in the case of electric potential, we can do what we cannot do in the case of temperature, that is, explain at once how electric potential may be estimated *quantitatively*. In this respect electric potential resembles level in gravitation; we have only to replace the unit of mass by the unit of electricity.

Def.—The difference of potential between two points is the number of units of work (*ergs*) done by electric forces on the unit of (positive) electricity in passing from the first point to the second.

Def.—An *equipotential* (or *level*) surface is a surface such that electricity has no tendency to pass from any one point to any other point upon the surface.

As in the case of gravitation, the zero of electric potential (or level) may be arbitrarily selected. For our zero of level we selected the Trinity high-water mark, a purely arbitrary zero. For the practical zero of electric potential it is usual to take the potential of the earth, which for many purposes may be regarded as sensibly uniform. In purely theoretical treatises the zero of electric potential is that of a point *infinitely* distant from all electrified bodies. Taking the potential of the earth as the zero of electric potential it follows that:—

The potential of a point is the number of units of work (ergs) done by electric forces and the unit of (positive) electricity in passing from the point to the earth.

This is, of course, equal to the number of units of work done against electric forces by an agent bringing the unit of electricity from the earth to the point, for otherwise "*perpetual motion*" could be shown to be possible.

It is very important to observe that *level* is an *attribute of a point* in the neighbourhood of the earth whether there be any *matter* at the point or not. Thus, in our foot-pound system of measurement, if we say that the level of a point is 1,000, we imply that 1,000 foot-pounds of work would be done on a pound in falling from the point to the sea level, but we *do not imply* that there is a pound or any other quantity of matter in the *immediate* neighbourhood of the point, whose situation with respect to the earth is alone sufficient to confer upon it the attribute of level.

Similarly, in the case of electricity, *potential* is an attribute of a point in space, and it does not follow that there is any electricity *at*, or *in the immediate vicinity of*, the point. Of course, there must be electricity somewhere in the neighbourhood, or there could be no electric potential, but the potential of a point is due to the electrification of all bodies which are sufficiently near to exert any electrical action at the point. Thus, a conductor may be at a high potential while its charge is zero, in consequence of other bodies positively electrified in its neighbourhood, and it may, and it often does, happen that a body is at a high *positive potential*, and is, nevertheless, *negatively* charged. This will happen when its own negative charge is insufficient to neutralise the positive potential due to positively electrified bodies in the neighbourhood.

When work is done by electric force on the unit of (positive) electricity in passing from the earth to any point, work will have to be done *against* the electric forces in bringing the unit of electricity from the point to the earth, and the potential of the point (like the level of points below Trinity high-water mark) is reckoned as negative.

When a positively electrified body tends to go from A to B a negatively electrified body will tend to go from B to A, so that, while positively electrified bodies tend to go from places of high to places of low potential, negatively electrified bodies tend to go in the opposite direction.

It is convenient to employ the term *electric field* for any portion of space in which electric forces act.

If a body which is a non-conductor (or insulator) be placed in an electric field, so that some points of the body are at places where the potential is higher than at other points (positive), electricity will tend to pass from the places of higher to those of lower potential, and this being resisted by the insulator stresses will be exerted on the substance of the insulator itself, which will thus be thrown into a state of strain. Thus, any non-conductor, or dielectric, placed in an electric field will experience a state of strain, resisted by the elasticity of the substance, and it is to this state of elastic strain of the dielectric that the *energy* of an electrified system is due. Sometimes the electric stresses exceed the elastic limits of the substance, and discharge takes place, which may be of a disruptive character, and cause the fracture of the dielectric.

If a conductor be placed in an electric field, positive electricity will flow from places of high, to places of low potential, causing the latter to become electrified positively, and therefore raising their potential, while the former become negatively electrified with a consequent lowering of potential. This action will go on until the potential at every point of the conductor is the same, and the distribution of potential throughout the field, as well as in the conductor itself, will, in general, be changed. This action is known as electric *induction*.

If a body be charged with positive electricity, and there be no other charged body in the neighbourhood, the body will thereby be raised to a positive potential, depending on the size and shape of the body, and the amount and distribution of its charge; for a unit of positive electricity in the neighbourhood of the body will be repelled by it, and work will therefore be done upon it as it goes away to the earth.

Similarly, a body charged with negative electricity and removed from the influence of all other electrified bodies will have a negative potential, for there will be a tendency for positive electricity to come from the earth to the body in virtue of the attraction of its negative charge.

But when a number of bodies are near together some charged positively and some negatively, the potential of any one of them will not depend on its own charge only, but in part on the charges of all the others, and thus it may happen, as indicated above, that a body with a negative charge may have a positive potential, and a body with a positive charge may have a negative potential.

Any conductor in communication with the earth must be at potential zero if there is electric equilibrium; for, if its potential were above that of the earth, electricity would flow from the conductor to the earth until equality of potential was produced, while electricity would flow in the opposite direction if the potential of the conductor were below that of the earth.

Thus, a conductor in communication with the earth, and placed near to a positively electrified body, will itself be electrified negatively in order that the potential due to its own negative charge may neutralise the positive potential due to the charge upon the positively electrified body, and thus reduce the potential of the conductor to zero. Similarly, a conductor in communication with the earth, and placed near a negatively electrified body, will itself be electrified positively.

In connection with every electrified surface a series of *equipotential* (or level) surfaces may be drawn such that the work done on the unit of electricity in passing from any point in one surface to any point in the next in order is equal to one *erg*. Such a set of surfaces would be analogous to the set of level surfaces described above, and, as in the case of

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gravitation, the *electric intensity* at any point will be inversely proportional to the perpendicular distance between successive equipotential surfaces in the neighbourhood of the point.

DEF.—The electric intensity at any point is the force which would act on the unit of electricity placed at that point.

Electric intensity is frequently called electromotive force *at* a point. Maxwell called it electric intensity in analogy with magnetic *intensity* and the *intensity* of gravitation. Instruments intended to *detect* differences of potential are called *electroscopes*. Instruments designed for the *measurement* of differences of potential are called *electrometers*.

It should be borne in mind that electroscopes and electrometers do not serve primarily to detect or measure *charges* of electricity, but simply the difference between the *potentials* of two points connected with each instrument, and called its electrodes, and hence of conductors in communication with the electrodes.

The gold-leaf electroscope consists essentially of two gold leaves suspended from a brass plate or knob by means of a brass rod, and protected from currents of air by a bell glass, through the neck of which the brass rod passes. The gold leaves should be surrounded by a wire-gauge cage placed within the bell jar, and having a wire attached to it which passes out through the stand of the instrument. The brass plate or knob then forms one electrode, and the wire attached to the gauge cylinder the other. If no gauge cylinder is employed, the walls and other objects in the room take its place.

ON LEADS FOR INCANDESCENCE LAMPS.

BY GISBERT KAPP.

In lighting by incandescence lamps, the resistance of leads becomes the more important the greater the number of parallel circuits feeding the lamps. To minimise the influence of lead resistance, it would be advantageous to place as much as possible the lamps in series, but to do that would be to encounter two great difficulties. In the first place, that of great complication in the arrangement of wires, and consequent necessity for the employment of highly-skilled labour, and, in the second place, that of making each lamp independent of all the rest. To make the light really serviceable for household and many industrial purposes, each lamp should be so arranged that it can be independently switched on or off, and if it be placed in series with one or more other lamps, this can only be done by the wasteful and complicated device of inserted resistances. By far the simplest, safest, and cheapest plan is, therefore, not to put too many incandescence lamps in series, but to work them as much as possible in parallel circuits bridging the two main leads. The number of lamps in each parallel will be determined by the unit of light desired. If, for instance, it were found convenient to have a unit of 60 candles, this could be made up of three 20 candle-power lamps placed in series, and then all the three lamps would be lighted or extinguished simultaneously. In most cases it will, however, be found convenient to have a unit small enough to be represented by one lamp, and in this case the difference of potential between the two main leads will have to be about equal to the electromotive force required to work one single lamp. It has hitherto not been found possible to construct reliable lamps of very high resistance and moderate candle-power, and 100 to 110 volts may at present be considered as the limit of electromotive force necessary to work small incandescence lamps.

The natural consequence of such a low E.M.F. is that the resistance of the leads ought to be as low as possible, because a high resistance would not only involve considerable loss of electric energy uselessly transformed into heat, but would also cause a difference of intensity of light according to the distance between lamps and electromotor. Let P_1 denote the potential at the positive terminal of the electromotor, this potential being expressed in units of any convenient absolute measure; P_2 the potential at the far end of positive lead, P_3 that at the far end of negative or return lead, and P_4 that at the negative terminal of the electromotor. In order that the current may flow in the assumed direction, P_1 must be greater than P_2, and $P_3 > P_4$. Therefore,

$$P_1 - P_4 > P_2 - P_3.$$

$E_1 = P_1 - P_4$ is the difference of potential or the electromotive force at the beginning of the leads; $E_2 = P_2 - P_3$ is the electromotive force at the end of the leads.

$$E_1 > E_2.$$

Let E be the electromotive force at any intermediate point, then

$$E_1 > E > E_2.$$

From this it will be seen that the brilliancy of the lamps (supposed all to be of equal resistance) diminishes as their distance from the electromotor increases.

To find the measure in which this takes place, we would require to know for each particular case the way in which the lamps are distributed along the main leads, and as there may be an infinite variety in the arrangement and grouping of lamps, it is impossible to treat the question in all its generalities. We will, therefore, confine ourselves to one special case, and select that of all the lamps being evenly distributed along the main leads. For practical purposes it is quite sufficient to investigate this case only, as it is the one mostly met with, and as it will be found easy to apply, with a little discrimination, the results obtained also to other and more irregular arrangements.

Let l denote the length of each main lead, and n the number of branch leads containing the lamps and bridging across the main leads.

The distance between two parallels is, therefore, $\frac{l}{n}$.

Let r be the resistance of each parallel, and g the resistance of each main lead between two parallels. We assume r to be constant for all the parallels. This is not absolutely correct, but sufficiently so for practical purposes; for it must be borne in mind that, although the lamp resistance depends to a certain extent upon the current passing the lamp, yet the variation in current which may be permitted is so exceedingly small that the corresponding variation in resistance can be altogether neglected.

To make the case amenable to mathematical treatment, we will further assume that the current, instead of being taken off at n fixed points, is permitted to leak gradually across the whole length of the mains. This leakage, however, must be considered to take place in such a measure that along the unit length of $\frac{l}{n}$ an aggregate amount of current just sufficient to feed one parallel is taken off. Let E be the difference of potential between the two mains at a point the distance of which from the electromotor be x, and let C be the current passing along the main leads at that point. To an increase dx of the distance corresponds a decrease dE in electromotive force, and a decrease dC of current—

$$-dE = 2gC\,dx,$$

$$-dC = \frac{E\,dx}{r},$$

$$\frac{dE}{dC} = \frac{2gr\,C}{E},$$

$$E\,dE - 2gr\,C\,dC = 0,$$

$$\frac{E^2}{2} - gr\,C^2 = K,$$

where K, the constant of integration, can be determined by applying the formula to the point $x = o$, that is, the beginning of the leads, in which point,

$$E = E_1, \qquad C = C_1.$$

Inserting the value thus obtained for K, we find

$$E_1^2 - E^2 = 2gr(C_1^2 - C^2). \quad . \quad . \quad (1.)$$

This equation gives the relation existing between electro-

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motive force at any point of main leads and current passing that point; but it does not say in what manner the position of this point influences either.

It was shown above that the electromotive force between the main leads, and consequently also the brilliancy of lamps, diminishes steadily towards the end of leads, where it is a minimum. For practical purposes we need, therefore, not trouble about intermediate points, as long as we find that the last parallel gets sufficient current. Let C_2 be the current through the last unit of main leads, and therefore, also, through the last parallel, then

$$\frac{E_2}{r} = C_2.$$

This equation combined with 1 gives

$$E_2 = \frac{1}{\sqrt{1 - \frac{2g}{r}}} \sqrt{E_1^2 - 2gr C_1^2}.$$

Let $R = \frac{r}{n}$ be the total resistance of all the n parallels, and $R_0 = 2ng$ the total resistance of main leads. It will be seen that $\frac{2g}{r} = \frac{1}{n^2}\frac{R_0}{R}$ is an exceedingly small quantity, which can be neglected. We have, therefore,

$$E_2 = \sqrt{E_1^2 - R R_0 C_1^2}. \quad . \quad . \quad . \quad . \quad (2.)$$

This formula is almost rigorously correct.

A less correct but still insufficiently approximate value for E_2 can be obtained by developing the square root into a series and neglecting the third and subsequent members, which are very small quantities. Approximately we can put $E_1 = R C_1$, and obtain

$$E_2 = E_1 - \tfrac{1}{2} R_0 C_1. \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

$R_0 C_1$ is the electromotive force necessary to drive the total current right along the main leads, supposing their far ends to be joined up and the branch leads to be all cut out. We have now the following easily-remembered rule. *The loss of electromotive force between the first and last parallel is equal to one-half the electromotive force which would be necessary to drive the total current right round the main leads if their far ends were joined up.*

This rule is, however, only approximately correct, and the approximation will be the nearer the smaller the resistance of main leads in comparison to that of the lamps. It would be quite correct if each parallel would get the same current; for in that case we have—

$$-dC = \frac{C_1}{n} dx,$$

$$-dE = 2gC\,dx,$$

$$\frac{dE}{dC} = \frac{n}{C_1} 2gC,$$

$$E = \frac{n}{C_1} gC^2 + C,$$

where K, the constant of integration, is found by applying the formula to the first parallel, where $E = E_1$ and $C = C_1$.

$$E_1 - E = n g C_1 \left(1 - \left(\frac{C}{C_1}\right)^2\right).$$

For the far end of the circuit, $E = E_2$, and $C = 0$,

$$E_2 = E_1 - n g C_1,$$

$$E_2 = E_1 - \frac{1}{2} R_0 C_1.$$

This is the same formula as obtained above. It is only correct if all the parallels receive the same current, as might be the case if they were clustered together about the middle of main leads. In this case the total current would be

$$C_1 = \frac{E_1}{\frac{R_0}{2} + R} \quad . \quad . \quad . \quad . \quad . \quad (4.)$$

In the case of the lamps being evenly divided along the leads, this value for the total current must be regarded as a first approximation to the real value. Similarly, we find as a first approximation for E_2 the value

$$E_2 = E_1 \frac{R}{\frac{R_0}{2} + R} \quad . \quad . \quad . \quad . \quad . \quad (5.)$$

This may now be used for finding a second and nearer approximation for the total current by the formula

$$C_1 = \frac{E_1 + E_2}{2R} \quad . \quad . \quad . \quad . \quad . \quad (6.)$$

Inserting this into formula 2, we get an almost mathematically correct value for E_2. Example:—

Sixty lamps, each of sixty ohms resistance, when hot are to be worked in single parallels, between two leads of $R_0 = 0{\cdot}1$ ohm total resistance.

Electromotive force necessary to bring the lamps to incandescence be 88 volts. Lamps evenly distributed. Neglecting the trifling resistance of short branch leads, we have $R = 1{\cdot}00$.

We assume $E_1 = 90$ volts.

By using formulæ 5 and 4 we have as a first approximation:—

$$E_2 = 85{\cdot}71,$$
$$C_1 = 85{\cdot}71.$$

Inserting this into 4 and 3 we find as a second approximation:—

$$E_2 = 85{\cdot}61,$$
$$C_1 = 87{\cdot}85.$$

The latter value inserted into 2 gives the almost mathetically correct value for the electromotive force at the end of main leads:—

$$E_2 = 85{\cdot}65.$$

Thus our 88 volt lamps would get 90 volts close to the electromotor, and only 85·65 volts at the greatest distance from it. The difference of 4·35 volts is almost too great to be compensated by the inequalities of the lamps, and slightly heavier main leads than those described above ought to be used in this case.

PHYSICAL SOCIETY, NOVEMBER 25.

Professor CLIFTON, President, in the Chair.

A paper by Mr. William Ackroyd on "Rainbows Produced by Light Reflected Before Entering the Raindrops" was read by the SECRETARY. The author investigated mathematically the rare phenomenon of three bows, and inferred that it would generally take place about sunrise or sunset.—Mr. LECKY thought the effect had a simple explanation. It might be said to be due to two suns, one (reflected) appearing to be below the horizon.

Mr. SHELFORD BIDWELL gave an account of some experiments he had made to test the theory of Dr. James Moser that the action of a selenium cell under light was due to the heat rays making a closer microphonic contact between the selenium and the metal electrodes by expanding the material. He submitted selenium cells to dark heat rays, and found their resistance to *rise*. Under light rays, however, their resistance fell. He therefore concluded that Dr. Moser's theory was erroneous, and that the fall in resistance due to the light rays is the differential result of the rise due to heat and the fall due to light. He also explained the "fatigue" of a selenium cell by use, as caused by its increase of temperature. When the cell cooled again the fatigue disappeared.

Dr. JAMES MOSER then read a paper on a "General Method of Strengthening Telephone Currents." This consists in forming a primary circuit of the telephone transmitter, or derived circuit, a set of induction bobbins in derived circuit, and a charged secondary battery, the whole circuit having a very low resistance. Each primary bobbin has a secondary wound over it, and these secondaries are connected "in quantity" to the telephone line, which has at its remote end a set of telephones in derived circuit to the earth or return wire. In this way one line more serves to supply a large number of separate telephones, a hundred being employed by Dr. Moser to transmit music from the Hippodrome in Paris to the Place Vendôme. The system is applicable to long lines, and the induction noises are reduced by subdivision among the separate telephones.

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CORRESPONDENCE.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I notice with much interest the letter from Mr. Cowley in your issue of December 2nd. It is certainly surprising that his friend should have found so much difficulty in purchasing accumulators, and I shall be pleased indeed to see any reason for the company's reluctance to sell.

It is to be hoped that in any future references to accumulators the information given will be more definite than has been usual in time past. For instance, in *The Electrician* of November 25th, there is a letter, signed "Ayrton and Perry," from which it may be inferred that, while travelling in a hansom cab, railway carriages, &c., they have kept three incandescent lamps burning. But, although the weight of the accumulator employed is given, no mention is made as to the duration and amount of lighting.

There is another matter which demands attention. In *The Electrician* for October 28th, Mr. Bosanquet says that some Faure cells, made by himself, underwent changes when left charged for any time. The acid was rapidly abstracted from the liquid, considerable quantities of sulphate of lead were formed, and this considerably impairs the efficiency of the battery.

We are naturally impelled to ask what is the cause of this. A secondary battery has been likened to a Leyden jar, but the leakage above referred to must necessarily be connected with some chemical changes which go on in this form of secondary battery. Now, so far as the chemistry is concerned, little or nothing was known until the researches of Gladstone and Tribe were published, and these throw a considerable light on the loss referred to by Mr. Bosanquet.

The difficulty of obtaining cells from the public companies, and the statements of Mr. Bosanquet, combine with many isolated facts to raise doubts as to the retaining power of accumulators. There is no doubt that the problems these batteries present are of a special order, and require special technical knowledge for their solution. But there is promise that the difficulties will be removed in the fact that qualified men like Mr. Bosanquet and Mr. Tribe are devoting their energies to improvements, and I trust that before long we may have a reliable storage battery.—Yours, &c., W. H.

Dec. 4, 1882.

A TELEGRAPH LINE WITHOUT INSULATORS, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I want to know what has become of James V. Fry. On October 28th you published a letter from him announcing that he had discovered two astounding facts, viz., how to construct a telegraph line 200 miles long without insulators, and how to make a galvanic battery out of pure rain water. On November 11th a subscriber, signing himself "M. Practical," wrote, recognising the great importance of these inventions, and asking for some particulars of them. These James V. Fry has hitherto disdained to give. Why? He says that he actually gave successful effect to both inventions in Japan. Either this is true or the reverse. If the first, let him say how he did it. If the second, James V. Fry's—if there is really such a person—silence is not difficult to understand.—Yours, &c., M. (PRACTICAL)^2.

London, Dec. 4, 1882.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am astonished that Mr. James V. Fry has not responded to the invitation of "M. Practical" in your number of Nov. 11, to explain *how* he worked 200 miles of wire without insulators, and *how* he made a voltaic battery with pure rain water.

He says he did these things, but carefully omits to state *how*. If some satisfactory explanation is not soon forthcoming, I, for one, shall know what to think of Mr. James V. Fry.—Yours, &c., INQUISITIVE.

Glasgow, Dec. 4, 1882.

RESISTANCE BOXES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The letter bearing signature "Student" in your issue of November 11 has received our due attention. We have carefully examined patent No. 212 of the year 1852, from which he has quoted, and have also taken opinion thereon (copy of which we shall be happy to forward to any one on application). We find the words, "iron wire of different thicknesses embedded in pipe-clay, alumen, or asbestos," as quoted by "Student" to be correct; but we would impress upon "Student" that he has quoted the words without the context. In the drawings, and by *necessity of construction*, the wires in this resistance are only *partially* embedded, showing clearly that Messrs. Slater and Watson were considering the matter of insulation and rigidity only, absolutely without reference to safety from fire or to diminution of the size of wire used for resistance purposes. Such a box the public are, of course, at liberty to make, though any system of embedding, in the sense and for the purpose of patent No. 5,743, of 1881, will be considered as an infringement of that patent.—Yours, &c., G. PFANNKUCHE

(for Pfannkuche and Dunston).

25, Charlotte-street, Fitzroy-square, W.C.,
December 6th, 1882.

OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If "J. A. S." would regard C (which he calls "the available force") as the quantity of electricity that flows through any section of a circuit in a unit of time, say a second, I think it would assist him.

When two bodies, unequally electrified, are insulated and connected by means of a conductor having a certain resistance, a current of electricity will flow from the body having the greater potential to the other, and should we employ a conductor having twice the resistance of the previous one, Ohm's law shows us that the quantity of electricity flowing through any section of the former in a second is twice as great as that flowing through any section of the latter in the same time.—Yours, &c., J. R. HARVEY.

20, Kent-road, Ford, Devonport,
December 5, 1882.

BOOKS ON ELECTRIC LIGHTING, LECTURES, &c.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could any of your readers recommend me a good practical book on electric lighting, including some of the more recent inventions. I should also be glad to know of any elementary lectures, in London, on mechanics and engineering, suited for an electrical engineer.—Yours, &c.,

STUDENT.

LECLANCHÉ BATTERIES, AGGLOMERATE FORM.

TO THE EDITOR OF THE ELECTRICIAN.

A correspondent writes:—"What length of time will the agglomerate plates of above last? Is there any test you can put to them to discover when nearly worked out other than the E.M.F. decreasing? Having just adopted them, shall be glad of any hints on their management."

[Our correspondent cannot do better than consult the India Rubber, Gutta Percha, and Telegraph Works Company, of Silvertown, E., for the information he requires.—ED. *E.*]

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THE ELECTRICIAN.

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THE BOARD OF TRADE AND ELECTRIC LIGHTING.

The deputation which waited upon the Secretary of the Board of Trade on Tuesday last with reference to the working of the Electric Lighting Act was a fitting commentary upon that premature and ill-considered measure. We have predicted all along that its provisions, so far from promoting the permanent interests of electric lighting, would provoke the hostility of the very people whom its friends desire most to conciliate; and this is actually what is occurring. On two or three quite distinct grounds the Bill was calculated to arouse opposition. It conflicts with those most highly cherished views of local self-government which, whether exaggerated or not, are facts the Bill seems to have wantonly disregarded. Practically, the whole power of the local authorities in relation to this particular business has been transferred by a side wind of legislation to the Board of Trade—really to its secretary for the time being. Further, it becomes plainer and plainer every day, although the statement has been denied many times, that the corporations are compelled, or may be compelled, to incur considerable sums on "experimental lighting," whether they like it or not. Now, much as the genuine advocates of electric lighting desire to convince the local magnates of its many advantages, they never wished their arguments to be backed by force. Indeed, force was just the very element most likely to be met by force, and if it comes to a question of fighting there can be no manner of doubt that even Mr. Chamberlain is no match for the united opposition of the local authorities.

There are other defects in the Bill; but we have dealt with them pretty fully in former articles. The two just referred to, however, were the main subject of remonstrance at the Board of Trade on Tuesday by deputations from the principal towns of England and Scotland. Their complaint is the more deserving of notice because it does not come from opponents of electric lighting. The deputation represented only those corporations which were desirous of dealing with the matter themselves—that is to say, they wanted powers to introduce the light under the control of their respective local boards, but with the liberty to exercise it when and how they might deem best. Nominally the deputation came to urge the desirability of making the use of the electric light permissive and not obligatory. But what they really meant was that their adoption of it should be permissive, whilst the exclusion of private undertakings should be obligatory. This might result in the corporations securing licenses for themselves which they never intended to use, except as a means of preventing the invasion of outsiders. It was against such action as this that, according to Mr. Chamberlain, Parliament was anxious to protect the would-be consumer. In reality we know very well that what Parliament was hurried into doing was to lend a helping hand to the speculating public, and if possible avert the financial catastrophe which was then threatening it. Still, there was the contingency that the local authorities might act the dog-in-the-manger, neither adopting the new illuminant nor letting any one else introduce it. At first sight such a course would appear most unreasonable; but everything turns upon the question of urgency. The Bill set out with the assumption that the general adoption of the electric light was possible and instantly needed. We sincerely wish it had been so. But the assumption was too transparent, as we have said from the first, to stand the test of calm reasoning; and, accordingly, we see the corporations asking for delay, for time to consider, to weigh the relative merits of the competing systems, and to adjust their local arrangements so that the introduction of a new system of lighting may not inflict upon the ratepayers a heavy pecuniary penalty.

Putting the most sinister construction on the representations of the various corporations who ask for powers, but have no present intention of using them, the case is one for compromise, not for compulsion. If this Bill had been for the promotion, say, of glass paving-stones or paper drain-pipes, its absurdity would have been evident from the first. Not that the use of glass and paper for purposes of that kind is absurd, but to legislate for their introduction into any and every parish would be. It would be worse than absurd, it would be a blunder, and it would fail. This is our complaint against the Electric Lighting Bill: We think it will fail to accomplish what the best friends of electric lighting are anxious should be accomplished, and what would have come

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about, perhaps, much better and quicker without any Bill at all.

We are afraid the deputation did not carry away much comfort from what the Secretary of the Board of Trade had to tell them. He mildly reproved them for not having foreseen what neither he himself nor the parliamentary committees appear to have foreseen; and likewise for not having stated their objections to clauses which they had no opportunity of seeing till the Bill was passed. He tried to impress them with the profound anxiety felt by Parliament for the promotion of "electrical sciences," and the pain it would suffer if any corporations or local authorities hindered or delayed the movement it had so much at heart. This was most touching, and in pathos was hardly surpassed by his reference to the "claims, duties, and privileges of municipal government." No man in England could have a higher opinion of them than himself. He believed that it was for the general good that everything should be done to add to the authority, the influence, and dignity of their local life. Perhaps the deputation were expected to infer that their immediate adoption of the electric light would greatly contribute to "the dignity of their local life;" but as regards their authority, he did not deny—he could not conceal from himself—he even admitted, that the Act of Parliament had placed very great discretion in the Board of Trade. Such of the deputation as have implicit faith in the great discretion of the Board may rest content on this; but they must not talk any more about the discretion of municipal governments, much less of their rights, for in this matter they have ceased to possess any.

The transfer of the rights of local authorities to the Board of Trade may, as we have before stated, give rise to much dissatisfaction as well as inconvenience. The present secretary told the deputation that he did not see how the Board of Trade could make any distinction between corporations and companies in reference to provisional orders. Neither do we, and perhaps it is right there should be no distinction in a matter of detail. But when it is a matter of distinguishing between one applicant company and another, on what principle, we should like to know, is the Board to make choice? Not by tender, not by local preference, nor, it may be hoped, by reference to quotations on the Stock Exchange. Perhaps this new-born zeal for science which Parliament has placed in the discreet lap of the Secretary of the Board of Trade may portend that every competing system seeking a provisional order will be tested scientifically before the order is granted. If that were the case, we should have no apprehensions about the result; but to transfer the responsibilities of the test to the local authorities, and to make them pay for the experiment, is almost certain to court determined opposition and ensure ultimate failure. One good result we may hope from this deputation, and from the very explicit answer which the Leeds authorities have received from the Board of Trade touching its interpretation of the Act, namely, that the competing companies alone will be left to fight the battle of electric lighting, without hindrance or patronage from local authority or Board of Trade.

STORAGE BATTERIES.—In reply to Mr. Cowley, several managers of companies have written to us stating that they are prepared to take orders and deliver storage batteries. We cannot undertake to advertise these companies' wares—that, we imagine, is a part of their business. We have performed our share of the work when we have shown that the want exists.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are contributed by E. C. RIMINGTON, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

11. What is the principle of a photometer? What form of photometer is most suitable for use with strong electric lights? What sort of results are obtained for the illuminating power of an electric light when it is examined through green and through red glass respectively? How does the intensity vary for beams at different angles in the same vertical plane for arc lights, and for incandescent lights—first, when a continuous current; second, when a reverse current is employed?

Ans. The principle of the photometer is that light varies inversely as the square of the distance; thus, if two lights give the shadows of a vertical bar on a white sheet of paper of the same intensities, and the distance of one is 40ft. and of the other 4ft. from the paper, the farther light will be 100 times the candle-power of the nearer.

The form of photometer best suited for measuring arc lights is the dispersion photometer of Messrs. Ayrton and Perry, in which the rays coming from the stronger light are passed through a concave lens (generally having a focus of 4in.), and thus rendered divergent. This method allows of the stronger light being placed much nearer the photometer than it otherwise could be.

When the rays of light from an electric arc lamp and a standard candle are passed through a sheet of green glass, the illuminating power of the lamp compared with the standard candle is greater than under normal conditions, when through red glass less.

The reason of this is that the standard candle contains more red and yellow rays than the arc light, while the arc light is far richer in violet rays than the candle. Now, when the two lights are passed through green glass, the blue in the glass absorbs a great part of the red and yellow rays, but allows the violet rays to pass with very slight loss. In the case of the red glass, the red and yellow rays are allowed to pass, while the blue and violet are absorbed.

In arc lamps, the greater the angle that the beam of light makes with the horizon when the lamp is suspended vertically the greater intensity it possesses. In direct current arc lamps, where the top carbon is the positive, the intensity is greater for a beam of light at any angle below the horizontal line passing through the arc than for the same angle above it. This is due to the crater that forms in the positive carbon acting like a concave reflector, and condensing the light downwards. In arc lamps worked by alternating currents the intensity is the same for the same angle whether above or below the horizon.

12. Describe, with sketches, the construction and action of any instrument you are acquainted with for measuring strong currents. What are the currents in amperes used respectively in the various systems of electric lighting?

Ans. The two instruments principally employed at the present time for measuring strong currents such as are employed in electric lighting are Ayrton and Perry's ammeter and Siemens's dynamometer. The former is simply a modified galvanometer, made exceedingly dead beat by the use of a very light aluminium pointer, and by making the needle move in a strong magnetic field. The coil surrounding the needle consists of ten strands, each of exactly the same resistance. By means of a commutator these ten strands can be joined either in series or in multiple arc. Thus the sensibility of the instrument can be increased ten times, either for the purpose of calibration, or for measuring small currents under three or four amperes. Siemens's dynamometer is constructed on the well-known principle that currents flowing in the same direction attract, and in opposite directions repel one another. It consists of two coils of wire, one fixed, the other suspended by a fibre and free to move. The movable coil generally consists of a very few turns of thick wire, and is mounted in mercury contact cups, so that the current enters at one terminal of the instrument, flows through the fixed coil, then through the movable coil, and out at the other ter-

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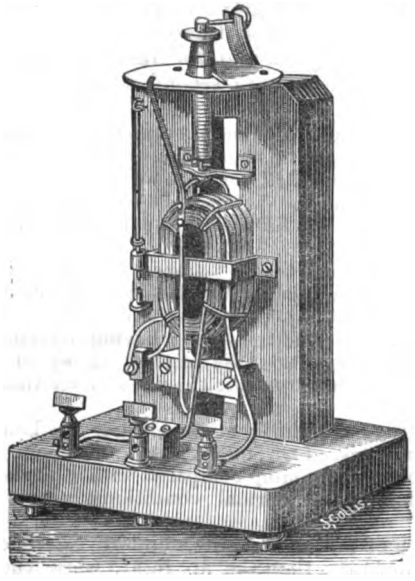
minal. A pointer is fixed to the movable coil, and vibrates between two stops on a dial at the top of the instrument; the top of this coil is attached to a fine brass wire torsion spring, the other end of which is fixed to a milled head, provided with a pointer, which can be turned round the dial. The dial is divided into 360 degrees.

When a current is sent through this dynamometer, the movable coil tends to set itself parallel with the fixed one, its pointer, therefore, moves against one of the stops, the milled head is now turned round till the torsion of the spring counteracts the attraction of the coils, the number of degrees registered by its pointer are then read off,

$$\text{when current} = \sqrt{\text{angle of torsion}} \times k,$$

where k is a constant found by calibrating the instrument. One great advantage of this form of dynamometer is that it can be employed with alternating currents. The currents employed to work arc lamps are generally from 10 to 20 amperes, while for



Siemens' Dynamometer.

the incandescent system they vary from 1 ampere, or less, to over 4.

13. Why does a spark occur in breaking the circuit of an electric lamp? Give a sketch of a switch so constructed that the spark on opening the circuit is very small. Why does no spark occur on closing the circuit?

Ans. When the circuit of an electric lamp is broken, the metal at the point where the interruption is made becomes vaporised, and a short arc is momentarily established across the space between the two portions of metal by reason of the conducting power of this vapour.

To prevent this some switches are constructed so as to simultaneously break contact at more points than one, thus reducing the sparking at each point to a minimum. On closing a circuit the reason no spark occurs is that there is no metallic vapour to conduct a current across the gap between the two pieces of metal. But even then, if we bring two wires having a very great difference of potential between them exceedingly near one another, a disruptive discharge occurs through the air, and an arc is established between them.

14. Explain in detail how electricity can be used for transmitting power, and how by its employment sources of power at present wasted may be practically utilised?

Ans. The motive power at command is employed to turn a dynamo, the current from which is conducted by wires to the place where the power is required. Here it is passed through a dynamo or electro-motor, which is thus made to revolve, and can be employed to perform the required work. In thus transmitting work the greatest electrical resistance should be where the power is to be utilised, *i.e.*, in the amature and field magnets of the electro-motor; consequently, the dynamo at the source of power must be of high E.M.F., and fairly low resistance, therefore it must be driven at a very high speed. The current of a river, or a waterfall, may be employed to turn a wheel, which is connected by means of gearing or straps with a dynamo. The ebb and flow of the tide might be utilised in the same manner.

15. How can the direction of rotation of a dynamo used as an electro-motor be reversed? Why ought an electro-motor not to be attached to the axle of a tramcar, and drive the wheels directly without the employment of speed reducing gear?

Ans. The only method of reversing the direction of rotation of an ordinary dynamo machine used as an electro-motor is to send the current in the same direction round the armature as when the dynamo was employed to produce a current, but in the reverse direction round the field magnets, or *vice versâ*. This can be done by reversing the connections of the field magnets with the armature.

To work an electro-motor economically it should be driven at a fairly high speed, that is to say, a speed much higher than the rate at which the wheel of a tram car revolves. We are consequently obliged to employ speed-reducing gear.

NOTE ON CHARGING SECONDARY BATTERIES AND ON A DYNAMO OF CONSTANT E.M.F.

BY R. H. M. BOSANQUET, ST. JOHN'S COLLEGE, OXFORD.

I should like to make some remarks on the interesting letter of Messrs. Crawley and Rimington in your number of Dec. 2, with reference to my notes which you reprinted from the *Philosophical Magazine*.

While I have no doubt that the method described by them is practical, it seems to me open to objection; and I still prefer my own method, though it may doubtless be improved, as I shall show.

When I start the machine with the resistance in circuit (I use about 6 ohms, not 5), the resistance ought to be so arranged that the speed of the machine is about the same as it will be when the accumulators are charging, and with the same power applied. The only point then necessary to be observed is to make the time of transfer, during which battery and resistance are in parallel circuit, very short, and to take care that there is plenty of power. It is easy to make the duration of the parallel circuit a second or so, and it may be made much less by a simple contrivance. Under these circumstances, the heavy load of the double circuit has not time to check the speed, and this proceeds unaltered. I find no difficulty in doing this by hand, making the contacts of the battery by a movement of the commutator with one hand, and releasing the resistance with the other. But it would be easy to arrange an overlapping contact for the resistance on the commutator handle, so that this should be done automatically by the one movement. I have often thought of doing this, but have never carried it out, as my present system is sufficient in practice. I did not describe my commutator, nor enter into minute particulars, as I wished to be concise, but I may say now that the commutator has three handles. Two control the parallel circuits, to right when machine is straight, to left when reversed; and the third joins them up, to right in parallel circuit, to left in series. The final contact is made with the third handle, and so with one movement.

There are one or two points requiring notice in the arrangement of Messrs. Crawley and Rimington. One is, that when cells are added they are short circuited during the overlapping contact. This does not matter if one remembers it and moves the handle quickly, otherwise mischief may ensue. I have burned my fingers before now in carrying out a plan of similar kind for changing the arrangements while charging.

The drop from the resistance of 5 ohms to that of the first 5 cells is a severe one; there is much more shock in this than with anything in my system. In adding 5 cells at a time there is a great risk of reversal when the margin of power is narrow.

It is not my experience that cells are more difficult to charge after an interruption. When the cells are in an unused condition I find the acid generally very completely absorbed, and the resistance high. I avoid continual additions of acid as much as possible, and at first it is sometimes difficult to get the current through. After a few minutes there is a great improvement, unless the cells have been idle for weeks, in which case they often give trouble for several

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days. This more than counterbalances the variation in the E.M.F.

While writing I wish to mention another subject, which is of great interest.

Early this year, in conversation with Mr. Swan, I observed that shunt circuit machines could not be used with common arc lamps (*e.g.*, Serrin), since the contact of the carbons would divert all the current from the shunt and stop the action. Mr. Swan suggested the employment of a main circuit as well to get over this, and pointed out that it was possible that such a combination might give rise to an E.M.F. which would be constant under varying external resistance. Lately I obtained Mr. Swan's permission to make use of the suggestion, and have worked the matter out. Since I did this I have seen (*Engineering*, Dec. 1, p. 530), a general description of a dynamo by Paget Higgs, in which I recognise the principle I have worked out. I believe also that machines are being made on this principle by Mr. Crompton. As I think that the investigation is of interest, I subjoin it. I have applied the numbers to the magnets of my Gramme machine, so that I may be treating of an actual case.

I suppose the shunt to be taken straight from the armature brushes.

Resistances.

R armature, r external, and main magnet coils, ρ shunt coils.

Number of Coils.

n main magnet coils, ν shunt coils.

E.M.F.

E total E.M.F., e between armature terminals.

$$\text{So that } e = \frac{r}{R + r} E$$

Intensity in axis of solenoid is $\frac{4 \pi n C}{L}$.

The length L is supposed given; then the magnetising force depends on nC, which I shall call coil amperes. In my machine, as it stands, n is 1,000 nearly; and the current is about 20 amperes when the machine is well excited, driving an arc light for instance. Then 20,000 coil amperes are required to excite the iron cores properly. These are to be supplied partly from a main and partly from a shunt circuit, so that

$$n C + \nu \frac{e}{\rho} = 20{,}000 \quad . \quad . \quad . \quad . \quad . \quad \text{(I.)}.$$

Vary the external resistance, denoting the change by an accent; then

$$n C' + \nu \frac{e'}{\rho} = 20{,}000,$$

subtracting $\quad n (C - C') + \nu \frac{e - e}{\rho} = 0;$

and by Ohm's law,

$$n E \left(\frac{1}{R + r} - \frac{1}{R + r'} \right) + \frac{\nu E}{\rho} \left(\frac{r}{R + r} - \frac{r'}{R + r'} \right) = 0,$$

whence $\quad n (r' - r) + \frac{\nu}{\rho} R (r - r') = 0,$

and $\quad \frac{n}{R} = \frac{\nu}{\rho} \quad . \quad . \quad . \quad . \quad . \quad . \quad \text{(II.)}.$

If this relation is satisfied, the number of coil amperes remains at 20,000, if it once has that value, independently of the external resistance; the excitation of the magnets is constant, and with constant speed the E.M.F. must be constant.

The number $\frac{\nu}{\rho}$ represents the number of coils of the shunt wire which go to 1 ohm resistance.

This is determined, if we assign the electromotive force to be used, and the coil amperes required. Putting the external resistance great, or not joining up the main circuit, we have from the first equation, leaving out n C,

$$\nu \frac{e}{\rho} = 20{,}000.$$

If we wish to work with E = 100—in this case e between the terminals = 100 also, and $\frac{\nu}{\rho} = 200$—the wire must be such that 200 coils have a resistance of 1 ohm on the average.

Then, from Equation II., $\frac{n}{R} = 200$ also. The resistance of my armature may be taken at ·5 ohm roughly; then $n = 100$, and 100 coils of the main circuit must pass round the magnets.

The length of shunt wire used determines the economy of the excitation of the shunt circuit. Suppose we used 1,000 coils; resistance, by above, = 5 ohms; current = 20 amperes; $e = 100$; volt amperes = 2,000, or between 2 and 3 h.-p. in exciting the shunt magnets. Suppose we use 10,000 coils; resistance = 50 ohms; $e = 100$; current = 2 amperes; volt amperes = 200, or about quarter of a h.-p.

In fact the number of volt amperes is,

$$\frac{e^2}{\rho} = e^2 \times \frac{200}{\nu},$$

and the horse-power is $\frac{e^2 \cdot 200}{746 \nu}$ for this wire.

It is easy to show by examples that the condition of constancy of excitation is satisfied.

Suppose R + r = 1 ohm, then R = . 5, r = . 5, C = 100^a, $e = \frac{1}{2} \cdot E = 50^\nu$ Then

$$n C + \frac{\nu}{\rho} e = 100 \times 100 + 200 \times 50 = 20{,}000$$

coil amperes, as before. The machine could not well be employed under these circumstances, as the heating of the armature would absorb nearly seven horse-power. Of course it was not constructed for such a purpose. The shunt excitation enables one to use higher resistances in the external circuit, and thus avoid the heating of the main circuit in the machine.

In my machine the average diameter of the coils will be about a foot. I find by calculation that 200 feet to an ohm gives ·12 centimetre for the diameter of a copper wire ·1. By measurement I find this to correspond to No. 18 B.W.G. This wire will carry more than two amperes, and the number of coils might be taken at less than 10,000, if economy of power is not a first object. Five thousand coils will absorb half horse-power when all the excitation is in the shunt. Less length than this would scarcely be admissible.

It only remains to be shown that in a shunt exciting circuit the power expended depends only on the weight of copper wire, when the wire is determined by the equation $\frac{\nu}{\rho} e$ = coil amperes required.

$$\text{Weight} = k \times \text{length} \times \text{section}.$$

$$\text{Resistance} = \kappa \times \frac{\text{length}}{\text{section}}.$$

$$\therefore \text{ weight} \times \text{resistance} = k \kappa (\text{length})^2$$

$$\text{length} = 2 \pi r \nu \ (r = \text{mean radius})$$

$$\therefore \frac{\text{resistance}}{\nu^2} = \frac{k \kappa (2 \pi r)^2}{\text{weight}}.$$

$$\text{Power} = \frac{e^2}{\rho} = \frac{1}{\rho} \left(\frac{\rho}{\nu} \times \text{coil amperes} \right)^2 = \frac{\rho}{\nu^2} (\text{coil amperes})^2;$$

whence, substituting for $\frac{\rho}{\nu^2}$,

$$\text{power} = \frac{k \kappa (2 \pi r \times \text{coil amperes})}{\text{weight}};$$

or the power expended in excitation of the shunt is inversely as the weight of copper, however the E.M.F. may vary, so long as the wire is determined for the existing value of E by the above equation. And there is no use in trying to economise by varying the E.M.F. and wire so long as the shunt coils furnish the chief excitation.

In the event of the machine being used as a motor, it would be necessary to reverse either the shunt or the main coils, as otherwise they would be opposed. The above arrange-

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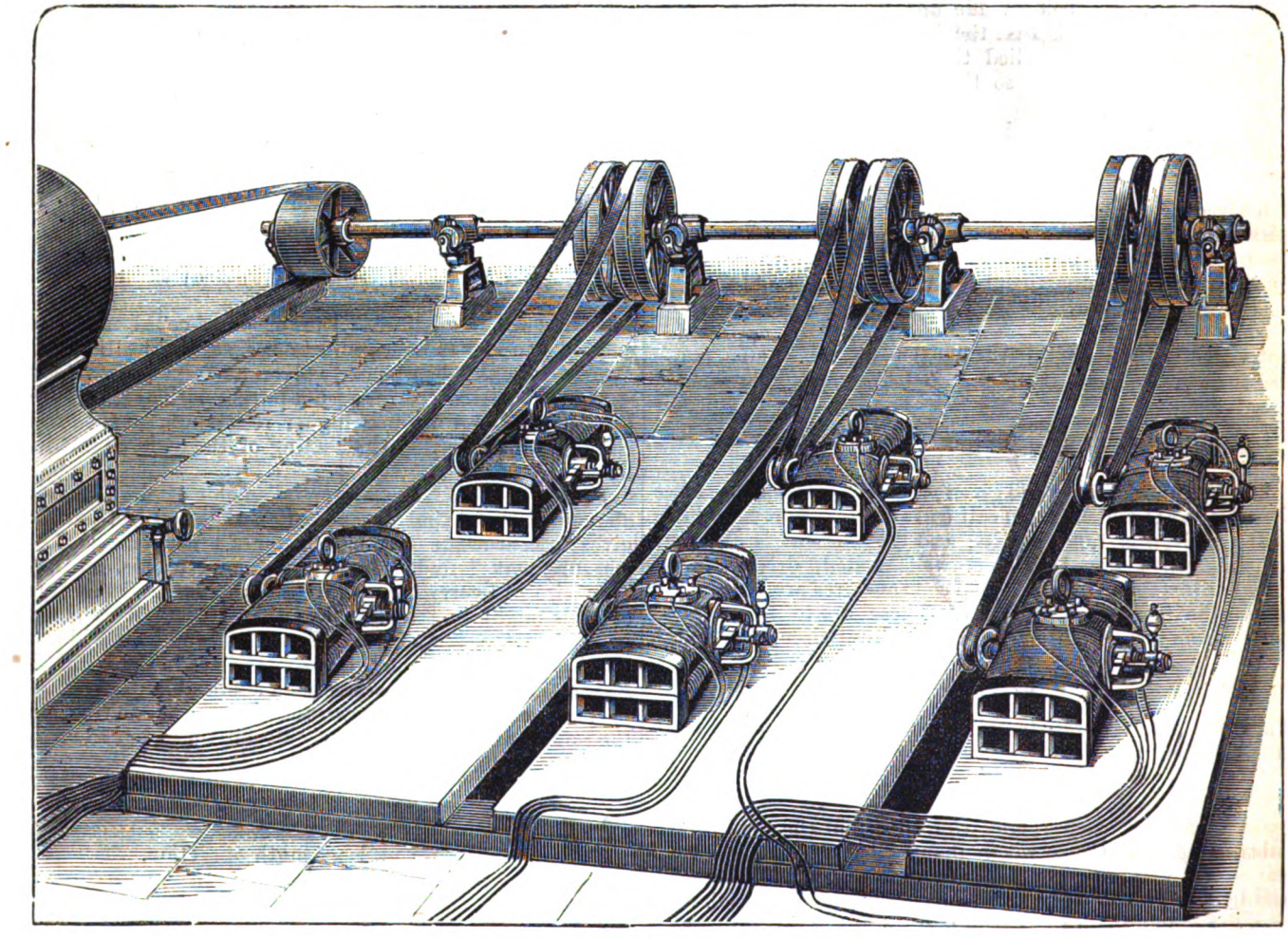
ment would have extraordinary advantages when thus applied, the main circuit exciting the magnets at starting, and the shunt circuit after the counter force is set up. The Gramme machine can never answer as a motor without shunt coils, for as soon as the counter E.M.F. is set up the main current is checked, and the excitation of the magnets falls. The shunt circuit is then a necessity.

THE ELECTRIC LIGHT AT THE LAW COURTS.

Herewith we give an illustration of the temporary machine room at the Law Courts. In our next issue we intend to give illustrations of the arrangement of the lamps in the interior of the building, as well as other details of the apparatus. Meanwhile, we may say that in the course of three weeks Messrs. R. E. Crompton and Co. completed the temporary light arrangements sufficiently to exhibit the light on Monday last, the day of the formal ceremony of opening the new Courts by the Queen. Crompton arc lamps are placed in the Great Hall and in the Quadrangle, Swan incandescent lamps in the corridors, staircases, Courts of Appeal, and adjoining Courts. The motor is a Marshall and Sons' engine, the dynamos are of the Bürgin type, as manufactured by Messrs. Crompton and Co. Over four miles of main wires have been laid in the building, and the fittings of most of the Swan lamps are complete and the lamps fixed. The light on Monday was very good indeed. Some of the details of the arrangements at the Law Courts are similar to but on a larger scale than those at Berechurch Hall, and, therefore, instead of illustrating the latter, as mentioned last week, we shall illustrate the former.



Arrangement of Dynamos at the Law Courts.

"IOLANTHE" AT THE SAVOY THEATRE.

Our readers need not fear that we are about to compete with "G. A. S." in the *Illustrated London News*, and to give a graphic description and criticism of the new play. We, like a good many others, have approved of recent plays provided under the management of Mr. D'Oyly Carte, but we approve more, perhaps, his practical appreciation of, and trust in, the electric light. His theatre is lighted by this means, and now he has proceeded further, and has included it among the accessories of personal adornment upon the stage That the electric light lends itself to this end must be admitted, but credit is to be given to the manager who inaugurated the use and the electricians who carried his ideas into effect. Some one signing himself "A. I. C. E." lately made himself and *The Times* ridiculous by writing to that paper of the dangers to be apprehended by this use of the electric light. The old saying, "A little knowledge is a dangerous thing," in this case was justified, and the knowledge "A. I. C. E." possesses amounts apparently to the value of x when x is infinitesimally small.

We give herewith illustrations of the apparatus in use at the Savoy Theatre, but with the remark that improvements have already been made and will probably be introduced in the course of a week or two. These improvements relate more to the weight to be carried than to other details. The apparatus is, we believe, the joint production of the Swan and Siemens Companies, and the carrying out of the arrangements has been in the hands of Mr. W. E. Rogers, who has the charge of the electric lighting arrangements at the Savoy under Messrs. Siemens and Co. It will be remembered that Messrs. Siemens have had the sole management of the electric light at the Savoy since the commencement of its use.

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The current is supplied at the time required by three small Planté secondary batteries of special construction. These cells are enclosed in gutta percha holders. Externally they appear as in Fig. 1. The hydrogen which escapes during the charging passes through small openings, which can be closed by coned stoppers, effectually avoiding any spilling of the acid. Shoulder straps are attached to the battery as shown, by means of which it can be carried like a knapsack, but as

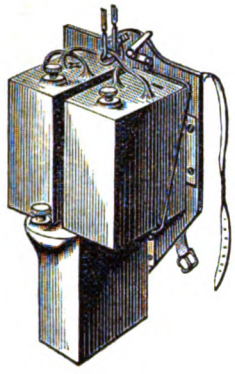

Fig. 1.

an additional security it is provided with a pair of hooks which are fixed into sockets sewn on the dress. The sketch of the lamp-holder, Fig. 2, and its connections almost explains itself. A flexible double wire is used which can be connected with the battery by forks of springy brass wires, supposing the apparatus fixed, and the light required. All that has to be done is to close the switch shown at the top of the battery. The whole

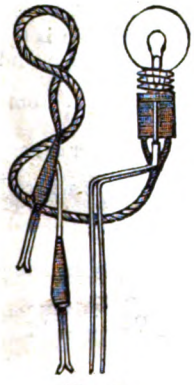

Fig. 2.

apparatus as now used weighs over 4lbs., but the improved apparatus is expected to weigh about 3lbs., perhaps less, no great weight certainly, nor dangerous in any way. It is intended, we believe, to use two cells instead of three, but we have seen a little lamp that can be worked by means of one cell. The lamps at present used give an intensely white light of about six candles. The E.M.F. of the battery is about 5 volts, and the current through the lamps about 1·5 ampere. Any per-

Fig. 3

son conversant with the veriest rudiments of electricity will know from this description, and from these figures, that harm to the fair skins of the wearers is about as likely as that the wearers will visit the North Pole before Christmas. Fig. 3 shows the lamp used. It is full size. We hope that the use of the light at the Savoy is but a forecast of its extensive use in theatres generally.

THE TRANSMISSION OF POWER BY ELECTRICITY.*

By Ll. B. Atkinson, Esq.

The rapidly increasing importance of electrical science, and of electrical engineering, makes it of interest that in a society devoting itself to the reading of papers on, and discussion of, engineering subjects, some attention should be paid at least to the chief problems attracting the attention of electrical engineers. By no means the least important and interesting of these problems consists in the efficient transmission of power from a source where it may be cheaply produced, to places distant or near, in large or small quantities.

Many attempts have been made to devise means for attaining this desirable result, the chief agents being water, ropes and belts, and air. Taking the last of these first, that is to say, air, a host of reasons at once are seen which practically exclude it from the transmission of any large amount of power. The chief of these is its great compressibility, which makes it necessary to employ pumps of great capacity and size, besides which it gives out great heat on compression, whilst when it gives out the work stored in it, it becomes so cold as to clog the apparatus with snow deposited from suspended moisture. Nevertheless, for the transmission of small quantities of power it can do good service. In Paris, for instance, a system of pneumatic clocks is established by means of which every few moments an impulse is given, by an apparatus at a central station regulated by a very accurate clock, to an air chamber, the pressure of the air is transmitted by pipes to the clocks, which have in themselves no regulating apparatus, and thus every quarter-minute, say, the hands are moved on. Again, the machine used at the Central Post Office for punching the perforated strips of paper used in the Wheatstone automatic telegraphic apparatus are actuated by compressed air. It will be unnecessary to remind you of the Westinghouse and other air brakes, or of the rock drills and tunnel borers worked by compressed air. All these are merely examples of the use of compressed air for the transmission of power.

The next agent I have enumerated is ropes and belts. Taking belts first, these for moderate distances, as in a workshop, are invaluable, and, on the whole, are a good method of producing motion at a distance. To use belts to the greatest advantage great speed is necessary, for the following reasons:—The work transmitted by any belt in a given time is measured by the difference of tension on the tight and slack sides multiplied by the distance through which the belt runs in that time. In order to use light and therefore cheaper belts, we must make the strain small and the distance great, that is, the belt must run fast. Besides this, for a belt running at a slow speed, there must be an excess of tension on both sides of the belts to secure adhesion, and this necessitates stronger belts, whilst, if a wide belt run very rapidly, a vacuum seems to be produced under it, so that the pressure of the air produces the necessary adhesion without excess of tension. To produce these effects the belt should be 3ft. to 5ft. wide, and should run at about 6,000ft., or more than a mile per minute.

The transmission of power by ropes, particularly wire ropes

Fig. 1.—Pulley.

Fig. 2.—The Relay Rope System.

which method was invented by Hirn, is much used in Germany, and with good results. The ropes should be of iron wire twisted on to hempen foundation. The pulleys must be V shaped, the bottom of the V being lined with leather. The ropes are worked on what are known as relays, that is about every 500 feet, the driving pulleys are made with two grooves, one rope ends, and another begins. The chief wear of the ropes takes place at the intermediate pulleys, which are necessary to support the rope. The ropes have to be renewed every year. The pulleys have to be relined with leather every two or three years.

Thus we have the very considerable disadvantage of expense attending this system of transmission of power.

The first I mentioned, viz., water, has at present by far the largest use and most extended application. This system has been brought to great perfection by Sir W. Armstrong. Briefly, the process is this. We have a large cylinder, in which works a piston or ram, supporting an immense load of scrap iron or

* A Paper read before the King's College Engineering Society. Printed by permission.

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bricks; this forms the accumulator. Water is pumped into this, thus raising the ram from the cylinder. Strong pipes are led to the point where the power is required. Here we have a smaller cylinder, with piston, which is acted upon when required by the pressure of the water. The advantages of this system are, 1st, the incompressibility of water; 2nd, the fact that the statical pressure which may be obtained is only limited by the strength of the materials of which the cylinder, ram, pipes, &c., are composed. But this system has several very serious disadvantages. 1st, friction. The friction over great lengths of pipe, particularly if it contain many bends, is very great, and moreover is proportional to the square of the velocity with which the water moves, and as all friction means loss of power, it is only when slow motion of the water is required that this system can be economically used. 2nd. If we want to transmit power intermittently, a very powerful objection exists in the large mass of water which it is necessary to set in motion, or, in other words, the great inertia of water which necessitates an expenditure of energy, and which energy when the motion is stopped is wasted, as heat, and which, were not air chambers provided, would burst the pipes.

The ordinary pipes for hydraulic work are 4″ to 5″ diameter, say 4″. Now, suppose we take a length of 100 yards, the volume of water $= \pi r^2 \times 300$ cubic feet $= 3{\cdot}15 \times (\cdot25)^2 \times 300 = 59{\cdot}06$ cubic feet. The weight of a cubic foot of water is about 63lbs. The mass is, therefore, $\frac{63}{32}$, which is sensibly equal to two units of mass. The mass of water is, then, 118 units of mass.

We know that the energy of motion of any body is

$$\tfrac{1}{2} m v^2.$$

The ordinary pressure in such accumulators is 800lbs. per square inch. The pressure on the cross section of the pipe $= \pi r^2 \times 800 = 3{\cdot}15 \times 4 \times 800 = 10{,}080$lbs. Every foot the water moves forward, 10,080 foot-pounds of work are done. To transmit one horse-power—that is, 550 foot-pounds—per second, the water must move with a velocity of $\frac{550}{10{,}080}$ feet, that is, 0·05 feet per second.

Putting this value in the above formula, $\frac{1}{2} \times 118 \times (\cdot05)^2 = 14{\cdot}75$, or, in 100 yards, 14·75 foot-pounds of energy are absorbed to set the water in motion; over a long distance, and transmitting greater power, this would be immensely increased.

The friction of solids depends, as is known, not on the area in contact, neither does it depend on the velocity, but only on the pressure, and the nature of the surfaces in contact. The friction in the case of liquids is precisely opposite in nature; it does not depend on the surfaces in contact, it does not depend on the pressure, but depends on the area of wetted surface, and on the velocity. The real place where the friction takes place is in the interior of the moving liquid, every particle revolving over its fellows.

Moreover, water cannot flow in a discontinuous curve; every bend produces an eddy, where energy is wasted. From all these considerations, we see that to employ water profitably we must have great pressure, acting through a small distance.

The limit to the pressure that may be used is practically defined by the great thickness of the pipes that are required, and by the difficulty of making joints, &c., watertight; 700lb. or 800lb., as I have before stated, is the usual pressure, though Mr. Twaddell uses as much as 1,400. I have now briefly sketched out the methods of transmitting power; if time permitted I should like to have gone more fully into them, but I must pass on.

In any system of transmission of power we have to consider mainly three things—*Economy, Efficiency, Effectiveness.*

These three may appear almost synonymous; but, although closely related, they are entirely distinct and separate. To give an example: An economical way of transmitting power would be to pump water up by means of a water-wheel, and then to let it flow to the required place, and there use another water-wheel. This would be economical, because we utilise a source of power costing nothing, but it would not be *efficient.* The *efficiency* of any machine, or series of machines, is the ratio of the work given out to the work put in.

Or, again, to transmit power by electricity generated by batteries would be highly efficient, but not economical.

We may transmit very small supplies of energy by means of a ray of light or heat, thrown by a mirror; this is efficient, it is certainly economical, but it cannot be called effective.

We can hardly say off-hand what will be the efficiency of any system of transmission unless we know the distance in all cases; in the case of belts we must know the speed, in the case of water the pressure, in the case of electricity the size of wire and the amount of current.

I will now, however, give the results of calculations giving us the general form for the efficiency of two of the systems mentioned, viz., water and ropes.

Efficiency of Transmission by Wire Ropes.

Let h = horse-power lost in friction,
$h = a\,(\cdot01\,n\,\mathrm{H} + \cdot025\,\mathrm{H})$ (Unwin's formula),
where H = horse-power put in, and n = number of 1,000 yards transmitted over.

Every relay is about 500 feet, so the number of relays will be $n \times \frac{3{,}000}{500} = 6n$; call this number of relays n'.

So $h = \cdot06\,n'\,\mathrm{H} + \cdot025\,\mathrm{H}$;

$$\therefore \text{ the efficiency } \frac{h}{\mathrm{H}} = (\cdot06\,n' + \cdot025). \quad . \quad . \quad . \quad . \quad (1).$$

Another rule gives—

$$\text{Efficiency} = \left(96\,\frac{n+2}{2}\right) \text{ per cent.} \quad . \quad . \quad . \quad (2).$$

Suppose we take ten relays, (1) gives $\cdot6 + \cdot25 = 85$ per cent.; (2) gives 96^6 per cent. $= 80{\cdot}13$ per cent.

Loss of Energy in Transmission by Water.

Let h be the head of water in any reservoir, the velocity of discharge, if there were no friction, is

$$v = \sqrt{2gh}.$$

If there is friction, we virtually diminish the head so far as the flow is concerned. Let the reduced head be $\frac{h}{\mathrm{F}}$.

F is of the form $\frac{4fl}{d}$, where f for iron $= \cdot0058$, for pipes lined with pitch $\cdot0042$.

$\therefore \mathrm{F} = \frac{\cdot0232l}{d}$, the quantity of water discharged per second is

$$\frac{\pi d^2}{4} \times v = \frac{\pi d^2}{4} \times \sqrt{2g \times \frac{hd}{\cdot0232l}} = 41{\cdot}3\sqrt{\frac{hd^5}{l}} = \mathrm{Q} \quad (1),$$

where d is diameter of pipe in feet.

The loss of energy due to friction is $\mathrm{Q} \times h$, where h is the loss of head due to the length of the pipe, and

$$h = \frac{\mathrm{Q}^2 \times l}{d^5 \times (41{\cdot}3)^2} \text{ from (1).}$$

Let P be the pressure in lbs. per square inch of the water being transmitted, then $\frac{\mathrm{P} \times 144}{62{\cdot}4} = \mathrm{H}$ is where H is the equivalent head of water producing the pressure,

and $\frac{\mathrm{Q} \times \mathrm{H} \times 62{\cdot}4}{550}$ = horse-power being transmitted

$= \frac{\mathrm{Q} \times \mathrm{P} \times 144}{550} = \cdot262\,\mathrm{Q}\,\mathrm{P}$ = horse-power being transmitted, call it E (2).

From (1) loss of energy $= \frac{\mathrm{Q}^3 \times l}{d^5 \times (41{\cdot}3)^2} \times \frac{1}{550} \times 62{\cdot}4$.

From (2) $\mathrm{Q} = \frac{\mathrm{E}}{\cdot262\,\mathrm{P}}$ $\therefore$ $\frac{\mathrm{E}^3 \times l \times 62{\cdot}4}{(\cdot262\,\mathrm{P})^3 \times d^5 \times (41{\cdot}3)^2 \times 550}$ = horse-power lost.

Horse-power lost $= \frac{\mathrm{E}^3 \times l}{p^3 d^5} \times \cdot00025$.*

Efficiency $\therefore = 1 - \frac{\mathrm{E}^3 \times l}{p^4 d^5 \cdot00025}$,

for $\mathrm{E} - \frac{\mathrm{E}^3 \times l \times \cdot00025}{p^4 d^5}$ is the horse-power arriving at other end.

h is in feet, l in feet, d in feet.

We now come to the transmission of power by electricity, and here I am placed in a difficulty, not knowing what knowledge of electricity and magnetism I am to assume possessed by the members of this society. It will, perhaps, be best to give a few preliminary explanations, and I can only hope that those who do not need them will not feel dissatisfied. It will be unnecessary for the present purpose to make any mention of the properties and nature of statical electricity, or electricity at rest, since all my remarks have to do with electricity in motion.

I suppose every one knows what is meant by a voltaic battery, an apparatus in which electricity is set in motion by means of a peculiar condition of dissimilar substances in contact, which condition is maintained by the oxidisation of some of the materials of the battery.

There are three terms which it will be absolutely necessary for

* Professor Perry's Cantor Lectures.

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me to explain before I go any further. These are "electromotive force and difference of potential," "current of electricity," "resistance" of a circuit. Electromotive force is a term applied to that force which tends to set electricity in motion, and must not be confused with a mechanical force produced by electricity in motion.

The potential of any point is numerically equal to the *work* that must be performed to bring a + unit of electricity from the earth to that point, and conversely is the work that would be performed by a + unit of electricity in passing from that point to the earth.

If there be two points at different potentials the difference of potential between them is the work performed in carrying a + unit of electricity from the one point to the other, and, conversely, the difference of potential is the work done by a unit of electricity in travelling from the point of higher to the point of lower potential.

Any two points at different potentials will, if joined by a conductor, tend to become of the same potential, this tendency manifesting itself as a flow of electricity from the one to the other.

Thus the only idea intended to be conveyed by potential is an idea of work done by electricity in motion between points of different potential.

If W be the work done by the unit in passing between two points at different potentials, and Q = the number of units, then $\frac{W}{Q} = V - V'$, where V and V′ are the potentials of the two points. This defines E.M.F. as the rate of doing work per unit of current.

A difference of potentials is, therefore, an electromotive force, but an electromotive force is not necessarily a difference of potential.

I will next make a few remarks about the term current of electricity. As I have just remarked, whenever two points at different potentials are joined by a wire, there is a tendency for electricity to pass between the two points and produce equilibrium. Now when electricity passes between two points we *assume* the existence of a *current* of electricity. The term current obviously connects itself with the hypothesis that electricity is a fluid; still, though this idea is upset, it is convenient to call the passage of electricity along a conductor a current. The term resistance is intended to denote that property of bodies in virtue of which it takes time for electricity to pass through them. Bodies of small resistance which are called good conductors allow a large quantity of electricity to pass through them in a short time, bodies of high resistance allow only a small amount to pass through them in given time, and hence are called bad conductors. I now want to try to explain to you a most important relation which holds good between these three things I have been talking about, viz., electromotive force or difference of potential, current, and resistance.

The relation I speak of is comprised in what is known as Ohm's law, from the name of its discoverer.

Ohm's law states that the strength of the current in any circuit varies directly as the *electromotive force*, and inversely as the *resistance* of a circuit. This is extremely important, and I must ask you to pay special attention to it, as I shall refer to it again very soon.

This may be written down—

$$C = \frac{E}{R}, \text{ or } C\,R = E, \text{ or } \frac{E}{C} = R.$$

By the strength of the current is meant the quantity of electricity which passes in a unit of time—in a second, in fact.

Not only do these relations hold in abstract formulæ, but, choosing proper units, they are numerically true.

I have not time here to go into the question of units, interesting as that question is; I can only state that the units employed by electricians are multiples of centimetre gramme second (C.-G.-S.) units, which system of units must in the end supersede all others.

The name given to the unit quantity of electricity is a coulomb, and a current of such strength that one coulomb per second passes any point is called an ampere, the unit difference of potential is one volt, which is very nearly equal to the electromotive force of a single Daniell cell. The unit of resistance is called an ohm.

So, as I stated above, we may use these units in Ohm's law, and the results we shall obtain will always be true.

An example will make this clear. Suppose we have 9 Daniell cells producing an electromotive force of 10 volts, what current shall we get through a circuit of 5 ohms total resistance? We have only to divide 10 by 5, and we get the answer—2 amperes.

$$\frac{E}{R} = C\,.\,\frac{10}{5} = 2.$$

Now for a few words with respect to magnetism. Every one knows, of course, what a magnet is, viz., a piece of steel which has the property of attracting iron and a few other substances, and that two magnets will repel or attract one another, according as similar or dissimilar poles are presented to one another's action.

Every magnet is said to have a field of magnetic force, that is to say all the space around it is under the influence of its magnetic action. Every force must have two elements included in any description of that force, these are magnitude and direction.

We may draw a magnet surrounded by a field of force, such that we may show both the magnitude and direction of that force at any point by the number of lines of force which shall cut a unit area (a square centimetre) at that point, such area being perpendicular to the direction of the force. I shall presently show the importance of thus mapping out the lines of force due to a magnet.

Fig. 3 shows such a field mapped out for a simple straight bar magnet having the poles at the two ends.

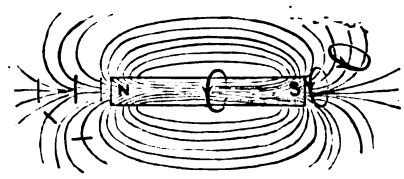

FIG. 3.

Now, I must mention a few of the relations between conductors carrying electric currents and magnets.

Suppose we pass a current through a long helix of wire, the coils of which are not in electrical contact, we obtain effects exactly similar to those shown by magnets. We get attractions for iron, we get attractions and repulsions between the dissimilar or similar poles of two such helices, and between a solenoid, as such a helix is termed, and a magnet, we get relations similar to those holding between two magnets.

By passing a core of soft iron down the helix, the iron becomes magnetised, and behaves just as a steel magnet, but the moment we stop the current, the magnetism ceases.

So we see that by means of a current of electricity we can produce magnetism, further by magnetism we can produce a current of electricity. In the discovery of this fact Faraday would have immortalised himself had he done nothing else in his life. As a matter of fact the production of a current by the motion of a magnet is a necessary consequence of the production of magnetism by a current, provided we admit the truth of the law of indestructibility of energy. I have not time here to give the proof of this.

To make a general statement it can be shown that, whenever we make any alteration in the number of lines of force passing through a coil of wire, we shall produce a current in that coil, and the electromotive force produced in the coil is directly proportional to the number of lines added or subtracted in unit time. It is also proportional to the number of turns of wire in the coil.

It is on this principle of the alteration of the magnetic field passing through coils that all the magnets and dynamo electric machines of the present day are constructed. They consist of two parts; 1st, the magnets, which may be permanent steel magnets, in which case we call it a magneto-electric machine, or they may be electro-magnets, formed by the passage of the current in the way I have above described. These produce the necessary magnetic field. 2nd. We have what is generally called the armature, which contains the coils, which are moved from one part of the magnetic field to another, thus producing the necessary alteration in the number of lines of force passing through the coil. In addition to this, if the machine is to furnish a current in one direction only, it must have a commutator, which is a contrivance which reduces all the currents produced in the coils to a common direction.

(TO BE CONTINUED.)

PROVISIONAL ORDERS.

APPLICATIONS TO THE BOARD OF TRADE, 30TH NOVEMBER, 1882.

The following is an alphabetical list of the towns for which provisional orders are being sought, together with some statistics, which we think may be interesting to our readers. We are

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indebted to Mr. Offor, manager of the South Eastern Brush Electric Light Company, for this table:—

Name of Town.	Company Applying.	Local Authority Applying.
Aberdeen	Brush	Burgh.
Accrington	—	Borough.
Altrincham	—	Local Board.
Aston	S. Staffordshire	—
Bath	—	Corporation.
Barton, Eccles, Winton, and Monton	—	Local Board.
Balsall Heath	S. Staffordshire	—
Beccles	—	Corporation.
Beckenham	—	Local Board.
Bedford	Provincial Brush.	—
Belfast	Incandescent	—
Birkdale	—	Local Board.
Birmingham	Incandescent	—
Birkenhead	—	Corporation.
Blackpool	—	Corporation.
Blackburn	—	Corporation.
Bootle-cum-Linacre	—	Corporation.
Bolton	—	Corporation.
Bradford	Union	Corporation.
Bury St. Edmunds	Provincial Brush.	—
Brighton	Union Company	Corporation.
Bristol	—	Corporation.
Buxton	—	Corporation.
Cambridge	Provincial Brush.	Imp. Commis.
Camberwell and Penge	Met. Brush	—
Canterbury	S. E. Brush	—
Carlisle	—	Corporation.
Chadderton	—	Local Board.
Chelsea	Met. Brush	—
Chelsea	Ferranti, &c.	—
Chester	Union	—
Chichester	—	Urban San. Authority.
City, Clerkenwell, and St. Luke's	Metropolitan	—
Colchester	S.E. Brush	Corporation.
Croydon	S.E. Brush	—
Cardiff	G. W. Brush	—
Cheltenham	G. W. Brush	—
Darlington	—	Corporation.
Dover	—	Corporation.
Dudley	S. Staffordshire	—
Dundee	Brush of Scotland	—
Dundee	Gas Commissionrs	—
Dublin	Dublin Elec. Light	—
Edinburgh	Brush of Scotland	Corporation.
Exeter	Union	—
Falmouth	—	Local Board
Folkestone	S.E. Brush	Urban San. Authority.
Fulham, Ealing, Acton, and Chiswick	Met. Brush	—
Glasgow	Brush of Scotland	Corporation.
Gloucester	Gt. West. Brush.	—
Grantham	—	Corporation.
Gravesend	S.E. Brush	—
Great Yarmouth	Provincial Brush.	—
Greenwich and Lewisham	Met. Brush	—
Greenock	—	Bd. of Police.
Hackney, Bethnal Green, and Shoreditch	Met. Brush	—
Halifax	—	Corporation.
Hampstead	Ferranti, &c.	—
Hampstead, Willesden, Hendon, and Finchley	Met. Brush	—
High Wycombe	Provincial Brush.	—
Holborn and St. Giles	Pilson-Joel	—
Hornsey, Highgate, and Southgate	Met. Brush	—
Hucknall Torkart	—	Local Board.
Hyde	Lancs. & Yorks.	—
Ipswich	Provincial Brush.	—
Islington	Met. Brush	—
Kensington	Met. Brush	—
Lambeth	Met. Brush	—
Leamington	—	Corporation.
Leeds	—	Corporation.
Leicester	—	Corporation.
Liverpool	—	Corporation.
City of London	Pilsen-Joel	—
City of London	Edison	—
Lowestoft	Provincial Brush.	—
London (Victoria District)	Swan United	—
London (Hanover-square District)	Swan United	—
London (Strand District)	Swan United	—
London (Strand District)	Met. Brush	—
Luton	Provincial Brush.	—
Maidstone	S. E. Brush	—
Manchester	—	Corporation.
Margate	S. E. Brush	—
Marylebone	Met. Brush	—
Nelson	—	Local Board.
Northfield	Incandescent	—
Norwich	Provincial Brush	Corporation.
Nottingham	—	Corporation.
Newngtn(St. Grge&St. Savours, Sthwark)	Met. Brush	—
Newport	G. West. Brush.	—
Newcastle-on-Tyne	—	Corporation.
Oldham	—	Corporation.
Over Darwen	—	Corporation.
Paddington	Met. Brush.	—
Paisley	—	Burgh.
Plymouth	—	Corporation.
Plymouth, Stonehouse, and Devonport	Union	—
Portsmouth	—	Corporation.
Preston	—	Corporation.
Pudsey	—	Local Board.
Reading	Incandscnt Lgtg.	Corporation.
Redditch	Incandscnt Lgtg.	—
Richmond (Surrey)	S. E. Brush	Vestry.
Rochdale	Union	Corporation.
Rochester and Chatham	S. E. Brush	—
St. Olave's, Bermondsey, & Rotherhithe	Met. Brush	—
St. Pancras (London)	Pilsen-Joel	Vestry.
St. Pancras (London)	Met. Brush	—
Stalybridge	Lancs. and Yorks.	—
St. Giles, Bloomsbury, and Holborn	Met. Brush	—
St. George's, Hanover-square	Met. Brush	—
Westminster and Soho	Met. Brush	—
St. Martin's-in-Fields, &c.	Met. Brush	—
Scarborough	—	Corporation.
Saltley	South Staffs	—
Sheffield	Union	Corporation.
South Kensington	Swan United	—
Southampton	Union	—
South Shields	—	Corporation.
Southport, Birkdale, and District	—	Corporation.
Stockport	—	Corporation.
Sudbury (Suffolk)	Provincial Brush.	—
Sunderland	North Eastern	—
Swansea	—	Corporation.
St. Helens	—	Corporation.
Todmorden	—	Local Board.
Tottenham, Edmonton, and Leyton	Met. Brush	—
Ulverston	—	Local Board.
Walsall	S. Staffordshire	—
Walsall	Incandescent	—
West Ham, East Ham, and Wanstead	Met. Brush.	—
Weston-super-Mare	—	Local Board.
Wakefield	Lancs. and York.	—
Wallasey	—	Local Board.
Wandsworth and Wimbledon	Met. Brush.	—
Wigan	—	Corporation.
Winchester	—	Corporation.
Wednesbury and Darlaston	S. Staffordshire	—
West Bromwich	S. Staffordshire	—
Wolverhampton	S. Staffordshire	—

Résumé.

		Companies.	Local Bodies.
Number of towns for which applications have been made	103	56	62
City of London	1	3	—
Metropolitan Districts	24	31	1
	128	90	63

Double Applications, viz., Companies and Local Bodies 14

Applications by more than one company for the same town: Country ..... 2; Metropolis ..... 7; City of London 3

LIST OF COMPANIES MAKING APPLICATION.

Brush Companies.	Name of Towns.
Brush of Scotland	Aberdeen.
Brush of Scotland	Dundee.
Brush of Scotland	Edinburgh.
Brush of Scotland	Glasgow.
Provincial	Bedford.
Provincial	Bury St. Edmunds.
Provincial	Cambridge.
Provincial	Great Yarmouth.
Provincial	High Wycombe.
Provincial	Lowestoft.
Provincial	Luton.
Provincial	Norwich.
Provincial	Ipswich.
Provincial	Sudbury.
South Eastern	Canterbury.
South Eastern	Colchester.
South Eastern	Croydon.
South Eastern	Folkestone.
South Eastern	Gravesend.
South Eastern	Maidstone.
South Eastern	Margate.
South Eastern	Richmond.
South Eastern	Rochester and Chatham.
Great Western	Cardiff.
Great Western	Cheltenham.
Great Western	Gloucester.
Great Western	Newport.
Metropolitan	Camberwell and Penge.
Metropolitan	Chelsea.
Metropolitan	City, Clerkenwell, St. Lukes.
Metropolitan	Fulham, Ealing, Acton, and Chiswick.
Metropolitan	Greenwich and Lewisham.
Metropolitan	Hackney, Bethl. Green, & Shoreditch.
Metropolitan	Hamstd., Willsdn., Hendn., & Finchy.
Metropolitan	Islington.
Metropolitan	Hornsey, Highgate, and Southgate.
Metropolitan	Kensington.
Metropolitan	Lambeth.
Metropolitan	Strand.

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Brush Companies.	Name of Towns.
Metropolitan	Marylebone.
Metropolitan	Nwngtn.,St.Gorg's,& St.Savr's,Stwk.
Metropolitan	Paddington.
Metropolitan	Bermondsey and Rotherhithe.
Metropolitan	St. Pancras.
Metropolitan	St. Giles, Bloomsbury, and Holborn.
Metropolitan	St. George's, Hanover-square.
Metropolitan	Westminster and Soho.
Metropolitan	St. Martin's-in-the-Fields, &c.
Metropolitan	Tottenham, Edmonton, and Leyton.
Metropolitan	East Ham, West Ham, & Wanstead.
Metropolitan	Wandsworth and Wimbledon.
South Staffordshire Company	Aston.
South Staffordshire Company	Balsall Heath.
South Staffordshire Company	Dudley.
South Staffordshire Company	Saltley.
South Staffordshire Company	Walsall.
South Staffordshire Company	Wednesbury and Darlaston.
South Staffordshire Company	West Bromwich.
South Staffordshire Company	Wolverhampton.
Incandescent Company	Belfast.
Incandescent Company	Birmingham.
Incandescent Company	Northfield.
Incandescent Company	Reading.
Incandescent Company	Redditch.
Incandescent Company	Walsall.
Union Company	Bradford.
Union Company	Brighton.
Union Company	Chester.
Union Company	Exeter.
Union Company	Plymouth, Stonehouse, & Devonport.
Union Company	Rochdale.
Union Company	Sheffield.
Union Company	Southampton.
Ferranti, Thomson, and Ince	Chelsea.
Ferranti, Thomson, and Ince	Hampstead.
Gas Commissioners	Dundee.
Dublin Electric Company	Dublin.
Lancashire and Yorkshire	Hyde.
Lancashire and Yorkshire	Stalybridge.
Lancashire and Yorkshire	Wakefield.
Pilsen-Joel	Holborn and St. Giles.
Pilsen-Joel	City of London.
Pilsen-Joel	St. Pancras.
Edison	City of London.
Swan United	Victoria District, London.
Swan United	Hanover-square District, London.
Swan United	Strand District, London.
Swan United	South Kensington.
North Eastern	Sunderland.

Résumé.

Brush Companies	51 Orders.
All other companies	38 Orders.
Country Town Authorities	62 Orders.
Metropolitan Vestry	1 Order.
	152

MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel on the 1st inst., "for the purpose of considering the offer which has been made by the Eastern Telegraph Company to purchase the telegraph lines and property belonging to the Mediterranean Extension Telegraph Company, upon the terms set forth in a letter from the solicitor of the Eastern Telegraph Company (a copy of which letter has been furnished to each shareholder), and to pass such resolutions as the majority of the shareholders may think proper." Mr. James Carmichael presided.

The SECRETARY (Mr. Tombs) having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, it will be within the recollection of all of you—at all events of all those present who were at the last meeting on the 31st August last—that I then informed you that negotiations were pending with the Eastern Telegraph Company for the purchase of our property. I told you then that these negotiations were not in a state that we could bring them before you, but that as soon as any definite proposal was made we should, before taking any further steps in the matter—before moving in any way to compromise your interests—lay the whole question before you and take your opinion before acting in the matter, and it is with this object and with this view that a circular has been addressed to you enclosing the absolute offer in the letter of Mr. Burt, the solicitor of the Eastern Company, that you might yourselves form an opinion of the offer and come here, meet together, and consult upon it. Now, I need not tell you that it would have been much more pleasant to us, the directors, had the offer been couched in a more liberal spirit, but, such as it is, it is our duty to lay it before you, and take your advice and have your opinion upon it, before either declining or accepting it, or doing anything with it. We could not to-day decide anything positively, or do more than ascertain the wish of the majority of the shareholders. If you were to decide on selling your property, it would then be necessary to call a special meeting, and I believe—our solicitor is present, and will correct me if I am wrong—we should have to go into liquidation, a friendly liquidation, and to appoint liquidators, and the Company would require to be dissolved. The liquidators would then sell the property to the Eastern Company. I think that that is the legal form, but the first thing is to ascertain your wish and the opinion of the meeting. Therefore we have asked you to come here to-day, and shall now be most happy to answer any questions you may put as far as we can, and consult with you on the best steps to be taken.

Mr. WILLIAM FORD desired to say that he did not object to the terms proposed, but, as an ordinary shareholder, he strongly objected to the proposed apportionment of the reserve fund in the manner stated in Mr. Burt's letter. He contended that it was beyond the province of the Eastern Company to make any suggestion as to the distribution of the reserve fund, which he held was entirely a question for the shareholders themselves. He trusted that if the meeting gave their assent to the proposal, it would be understood that they did not give their assent, either directly or indirectly, to the apportionment of the reserve fund, which had been created at the expense of the ordinary shareholders.

The CHAIRMAN said he quite agreed with Mr. Ford that the distribution of the reserve fund was entirely a shareholders' question. Mr. Burt's remark as to the reserve fund was only a suggestion, however.

A SHAREHOLDER inquired in what way the preference shares were preference shares.

The CHAIRMAN said that the preference shares had been raised on two separate occasions, many years ago, with the object of laying down new cables. In further reply to the shareholder, he added that the shares were only preference as regarded dividends.

Captain TURNER desirered to know if the directors recommended the offer which had been made by the Eastern Company.

The CHAIRMAN: The directors have carefully abstained from making any recommendation for or against it. I think it is much better that we should leave this question as a shareholders' question. If you ask me my opinion, I will give it, but not as chairman of the board. It is a difficult subject to give an opinion about, as I might be accused afterwards of giving an opinion in favour of an offer that might prove disadvantageous. It is quite a shareholders' question, and I have my opinion of it as a shareholder.

Captain TURNER remarked that the directors must know a great deal more about it than the shareholders.

Mr. ADAMS suggested that the chairman should give his opinion of the offer as a shareholder.

The CHAIRMAN: Well, there are shareholders and shareholders. There are original shareholders, and I am one of them, who unfortunately paid £10 a share. There are those who came in on much more favourable terms, varying from £2 and £3. Then there preference shareholders. There are so many shareholders who must have, to a considerable extent, different interests. As an original shareholder, and as having paid the full value for my shares, I say that I do not wish to part with my property at the price offered. Many others may think it desirable to accept this offer, and I should not like to stand in their view. Whatever may be the shareholders' wishes, we shall carry out loyally. We thought it our duty to point out to you the worst that could happen to you—that the Government guarantee ceases from the 4th of this month, in four days more; and then, if we go on, we must rely entirely upon our own resources for earning any dividend at all, and at the present moment we should not be able to pay the ordinary shareholders anything. We could, I presume—indeed I know—we could pay the preference shareholders something, but not eight per cent. There are prospects of improving the traffic, and, as you know, the Mediterranean is a big lake, and the Eastern Company may not always have the monopoly of the lake. We have an important position at Malta, and we might have other offers. We must not deceive ourselves, however. If we go on we shall have to rely entirely on our own resources. There is another thing I must tell you. I do not see that we can work much more economically than we are doing. We have been under Government supervision, we have had a Government director on our board, and we have worked with the greatest economy. I do not think we could cut down much more. The Italian concessions are mentioned in our circular. One of them has seven, and the other nine years to run, and they are exclusive concessions as regards Sicily and the South Coast of Italy.

Mr. ADAMS thought the directors should know pretty well what the resources of the Company were, and in face of what the chairman had said as a shareholder, he thought they should not deal with the Eastern Company on the very low terms which had been offered. There was scarcely anything for the ordinary shareholders, who, he said, would have to take 20 per cent. off the amount of the 4 per cent. debenture stock.

The CHAIRMAN: Hardly as much as that.

Mr. ADAMS (continuing) suggested whether it would not be desirable to see if something better could not be done rather than give up the Company altogether on the terms offered, particularly as they had an offer of something like double the present amount twelve months ago.

The CHAIRMAN: No; this is the first definite offer we have ever had in writing, and I wish it had only been more liberal.

Mr. ADAMS remarked that had the offer been more liberal it would have been accepted; and a more liberal offer could have made very little difference to such a powerful company as the Eastern Company. He thought shareholders should be guided by the opinion expressed by the chairman that the offer was not sufficient. The debenture stock offered was not as if it were on land or on a railway. If they had a war and could not get to their "rope," what would the debenture stock be worth? Perhaps the meeting might be informed how far the shareholders had given their opinion by proxy respecting the offer. As far as he could see the Company would earn considerably more for the preference shareholders than the preference shareholders would get by accepting the offer.

The SECRETARY remarked that the earnings last year would have given the preference shareholders 5 per cent.

The CHAIRMAN stated that they had sent out proxies to every shareholder, but not a fourth of the capital was represented by them. There were about 83 shareholders in favour of the offer, 13 against it, and 20 had sent their proxies to the directors to vote as the directors thought best. He, however, did not think it was quite fair to wish to place such a responsibility on the directors. 693 shares were represented by the proxies of the preference shareholders. The proxies were almost entirely from ordinary shareholders. There was but a very small amount of preference shares. He inquired whether any preference shareholders were present who would give their opinion of the offer.

Mr. VEARES stated that he had read the circular which had been sent out by the directors impartially, and he had gathered from it that they recommended the offer.

The Hon. A. PONSONBY dissented.

Mr. VEARES stated that the document had been sent out from headquarters, and he certainly thought it urged the importance of a decision,

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terms having been put forward with that object. He was surprised at the little expression of opinion among the shareholders as to the offer. The chairman had said that he had paid £10 for his shares, and was sorry that the offer was not better, and they had had a few remarks from another shareholder, but he (Mr. Veares) thought that the present was the time to elicit opinions from one another on which the Board might base their views. He confessed that he did not know how to decide. If forty out of fifty were for it he should go with the forty; but two gentlemen had spoken, and had placed before them such confounded difficulties that he did not know how they were to act. He would ask the Eastern Company whether as regarded the offer they had made they were doing unto others as they would be done unto. They wanted this Company's property, and they came forward and made an offer when the market was depreciated. He was neither opposed to nor in favour of the offer, but he did complain of the nothingness of the chairman's remarks. The offer was very small, but it now appeared from what one gentleman had said that there was something to come off even the £1 12s. that was offered for the Ordinary shares. He thought that the Eastern Company's debentures were at something like 100.

The CHAIRMAN said that there were no debentures of the Eastern Company in the market.

Mr. NICHOLLS suggested that the meeting should be adjourned, and that a committee of two ordinary and one preference shareholders should be appointed to confer with the directors and report to a subsequent meeting as to the desirability of the offer being accepted or rejected.

Mr. J. L. CUTHBERTSON thought that previous to such a motion being put there should be further discussion. He was an original shareholder, not a preference shareholder, nor had he trafficked in the shares from the commencement. He asked the chairman if he was connected, directly or indirectly, with the Eastern Company.

The CHAIRMAN: I am not.

The Hon A. PONSONBY and Mr. C. H. ROBINSON also replied that they were not.

Mr. CUTHBERTSON thought the answer satisfactory, and observed that the preference shareholders, having regard to the position which they occupied, had been receiving a large dividend for a number of years, seeing that they could only receive what the Company might earn. He, therefore, thought that the difference in the price offered for the preference and the ordinary shares was preposterous, because if the Company was earning nothing, or only a trifle, the preference shareholders could not be in a different position from the other shareholders. He did not see why the Company could not go on. If the preference shareholders met the ordinary shareholders in an equitable manner, and reduced their interest, he thought the ordinary shareholders might contrive, with the aid of the reserve fund, strict economy as regarded the salaries to the officers, and remarkably small fees to the directors, to go on. He was an original shareholder, like the chairman, and he did not feel inclined to receive 24s. and five-eighths per cent. for his money. In fact he would almost lose the lot. He thought the preference shareholders might fall in with his views at a subsequent meeting. He did not think that the shareholders, either original or preference, should accept the present offer. Before they proceeded further, he thought what he had said might be considered.

Captain TURNER would make one more appeal to the chairman and directors, and thought in a matter such as this they should give their opinion and advice regarding the offer, since they knew the whole circumstances of the case.

The Hon. A. PONSONBY said that he had been asked to give his opinion of the offer as a director, but that he declined to do. The Board had been called upon to get certain terms from the Eastern Company, and they now brought them to the shareholders to decide upon. As the chairman had very ably remarked, there were some shareholders who had given £10, and others £5, while some gave £2 for their shares, or even less. Those who had given less might make something out of the sale, but those who had given £10 would lose. Consequently the directors as directors could not give them advice as to the offer. Speaking as a shareholder, however, he unhesitatingly said that he objected to the proposal; but, notwithstanding, he should go in accordance with the shareholders' wishes. He held 170 shares, and should vote with the majority, whichever way it went; but, individually, he was opposed to the offer, which he regarded as the very minimum that could have been made. In the twenty-four years they had existed they had paid the Eastern Company as intermediaries £7,000 a year. There was no doubt that, with speculation and with business improving, other lines would be opened up throughout the Mediterranean, and they could show a profit to Alexandria to someone who would lay down a wire of £7,000 a year. They had still the concessions referred to from the Italian Government, and he did not see why they should sell their concern at present, when they were at their very worst. He had the greatest respect for many of the gentlemen connected with the Eastern Company, but he did not believe they would give sixpence more than they could help. As to the fees of the Board, the directors would be willing, if the Company went on, to meet the views of the shareholders, although they certainly did not get much. As regarded the salaries to the officers, however, they were as low as they could be and much reduction could not be expected. The Government last year paid £1,760 for the repair of one of the Company's cables; but, in future, if they went on, they would have to bear the cost of repairs themselves. The letter of the Eastern Company showed the worth of the property at the market price, and he did not wish to give any opinion as to the relative rights of the preference over the ordinary shareholders.

Mr. C. H. ROBINSON, speaking not as a director, but as an independent shareholder, acquiesed in the views of the chairman and Mr. Ponsonby. He had been a shareholder in the Company for a great number of years, and when he sat on the shareholders' side of the table he had always advocated the necessity of an amalgamation with the Eastern Company. Since he had been a director his endeavours had always been directed to produce that result. He had an interview with Sir James Anderson, the result of which he communicated to them some ten or eleven months ago. It was a proposition to give the ordinary shareholders £2 10s. in money, and for the preference shares a debenture stock and three per cent. for it. That was submitted to a meeting some time ago, and the sense of the shareholders, one and all, was that they would not take less than £3 for the ordinary shares. That communication was made to the Eastern Company, who, he believed, made the matter nugatory for the time being. Since then negotiations had been passing between them, and they had resulted in the present offer, and how the discrepancy had arisen in eleven months between £1 12s. and £2 10s., he could not see. In his opinion the Eastern Company wanted this Company's line, but if the shareholders resigned all power over their property they would entirely shut themselves out from any benefit arising out of the chapter of accidents that were daily occurring in their own experience of new companies being brought forward and their receiving better offers. There were always persons who, if there was a basis to go upon, thought they saw a chance of making an extension of that basis. Mr. Ponsonby had told them what this Company paid to the Eastern Company annually for messages going over their lines, and if a cable of this Company's, which was now lying dormant, was raised up, and a company was started to go to Alexandria, they would so tap the Eastern Company that they would pay a very handsome dividend on this Company's property as well as to any one who would lay a cable to Alexandria. They had paid to the Eastern Company altogether for messages going over their line £165,000.

The CHAIRMAN observed that loose calculations ought not to be made.

The SECRETARY stated that he had taken the figures out.

Mr. ROBINSON observed that the 4 per cent. debenture stock which the Eastern Company offered would not be worth more at the outside than, say £85 to £90, and therefore the actual offer of £1 12s. would be considerably reduced. The £40,000 which the Eastern Company offered them in debenture stock would be, at 4 per cent., £1,600 a year; but they would save almost the whole of that in working and other expenses, as their Company could do this Company's work at very little more cost than their present expenditure. He calculated that the Eastern Company would be getting this Company's property, if they sold for the present offer, for about £400 a year. As a shareholder the offer appeared to him to be sadly too low, and the least minimum market price had been taken. He believed that that day they could get in the market £1 17s. 6d. for that which the Eastern Company offered £1 12s. for. However, it was a shareholders' question, and the directors did not wish to bias in any manner the opinions the meeting chose to advocate, which the directors would faithfully carry out.

The CHAIRMAN, in reply to Mr. Beck, said that he believed that in the event of the offer being accepted the Eastern Company would take over some of the Company's staff at Malta, but none here; nor did he think they would take over any of the Corfu staff, where one gentleman had been with this Company for twenty-four years. He thought it would be the duty of the directors to compensate their officers. Their secretary had been with them for thirteen years, their head clerk eleven years, and one of the officers at Malta twenty years.

A SHAREHOLDER inquired what steps had been taken to obtain a renewal of the agreement with the Government.

The CHAIRMAN stated that he had addressed a letter to the Secretary of the Treasury which was very short, and gave a little history of the Company. The letter was dated the 25th August last, and was as follows:—"Sir: I have the honour to submit the following proposal on behalf of the Mediteranean Extension Telegraph Company, which I trust may meet with the consideration of the Lords Commissioners of the Treasury. This company was originally constituted under the sanction of the Governments of Great Britain and Sardinia in 1857 with the object of connecting the islands of Sardinia, Malta, and Corfu by submarine cable, and a guarantee of 6 per cent. per annum was given by Her Majesty's Government on £120,000, the original capital of the company, for a period of twenty-five years. The cable between Cagliari (Sardinia) and Malta was subsequently destroyed by volcanic eruption at the bottom of the sea; and the line between Corfu and Malta being also interrupted, a fresh arrangement was made with Her Majesty's Government by which the guarantee was confirmed, the company laying down two new cables—one between Malta and Sicily, and the other between Corfu and Otranto—to replace the original cables which had been lost. The traffic on both those lines, and especially on that between Malta and Sicily, proved very satisfactory, and during several years only a small amount of the guarantee was required from Her Majesty's Government, and between the years 1863 and 1866 no call whatever was made on the Treasury in that respect. In 1869 the Anglo-Mediterranean Telegraph Company, now the Eastern Telegraph Company, duplicated their line between Malta and Alexandria, and called upon the Mediterranean Extension Company to lay a second cable between Malta and Sicily, as they maintained that one line would prove insufficient for the traffic between Alexandria and the European continent. The Mediterranean Extension Company accordingly raised additional capital and complied with the request. But shortly after the establishment of this second line between Malta and Sicily, the Anglo-Mediterranean Company extended their line from Malta to Gibraltar, and thence to Lisbon and Falmouth, and thus diverted to their new route all the messages between England and the East which had hitherto passed over the wires of the Mediterranean Extension Company. A concession was subsequently granted by the French Government to Baron Erlanger for the establishment of telegraph lines between Marseilles and Bona (Algiers), and from Bona to Malta, and Her Majesty's Government, notwithstanding the earnest protest of the Mediterranean Extension Company gave permission to Baron Erlanger to land and work his cable at Malta, which naturally proved most prejudicial to the interests of both the Company, and Her Majesty's Government, as these new lines, which were afterwards sold to the Eastern Telegraph Company, abstracted all the traffic between Egypt and France which had been previously transmitted by the Mediterranean Extension Company's cable, *via* Sicily and Italy. I would, however, beg to draw my lords' attention to fact that notwithstanding these heavy blows, and the severe loss of traffic sustained by the Company, they continued to manage their business with so much economy, and with such partial success that up to the present moment the average payment made by the Treasury has only amounted to £3,231 per annum, while under the guarantee Her Majesty's Government were liable to the payment of £7,200 per annum, or more than double the amount actually received by the Company. But the period of terminating the agreement between Her Majesty's Government and the Company is now approaching, and it will legally become void on the 2nd of December of the present year. I am, therefore, induced to lay this short statement before my Lords, and to solicit the renewal of the guarantee of Her Majesty's Government in such a modified form as they may consider advisable. I am aware that telegraphic communication with Corfu is no longer of any importance for Government purposes, but I venture to sub-

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mit that it would be clearly to the advantage of Her Majesty's Government to grant a small subsidy rather than abandon an existing telegraph line with Malta, by which messages could be sent to and from Great Britain, either through Italy and France or through Italy and Germany. Should the cables between Malta and Gibraltar, or between Gibraltar and Lisbon and Falmouth become at any time interrupted, this alternative line of communication might prove invaluable to British interests and Her Majesty's naval and military departments, especially in the event of certain political complications in the Mediterranean, which might possibly develop from the present critical state of affairs in Egypt. The Mediterranean Extension Company could not, however, hope to continue the working of this line between Malta and Sicily in face of the severe competition already mentioned without some encouragement and support from H.M. Government, and I therefore trust my Lords may be induced to grant a renewal of a portion of the present guarantee on condition of the line being maintained in good working order." That is signed by myself as chairman of the Company, and a copy of it was forwarded to H.M. Secretary of State for War and to the Lords Commissioners of the Admiralty for their information, and from them we have had an acknowledgement of the receipt of the letter. On the 17th October we got this answer from the Treasury:—"Sir: I have laid before the Lords Commissioners of H.M. Treasury your letter of the 25th August last, requesting that the guarantee of H.M. Government might be continued to the Mediterranean Extension Telegraph Company (Limited) after the expiration of the present agreement on the 2nd of December next. I am directed, in reply, to inform you that my Lords regret they can hold out no hope of a prolongation of the present agreement after its expiration on the 2nd of December next, or of a renewal of the guarantee of H.M. Government in a modified form." That is signed by Mr. Courtney. You see from that letter that we have done our best, and that the Government decline to do anything further. In fact, as I said, we are left to our own resources, and it appears to be the general opinion of the meeting that we can rely on those resources. If you wish us to appeal to the Eastern Company to see if better terms can be obtained we will do so, and perhaps that would be the best course.

Mr. Adams thought there was an amendment before the meeting.

The Chairman did not think the amendment had been seconded.

Mr. Adams thought that the feeling of the meeting was that the matter should be postponed, seeing the difference in the amount offered previously and that offered now. If the affair were postponed for three months, they might see whether something better could not be obtained.

Captain Turner: I beg to propose "That this offer of the Eastern Telegraph Company be rejected."

Mr. Beck: I second it.

The Chairman put the motion in the usual way, and declared it carried unanimously.

The Hon. A. Ponsonby (to Mr. Adams): Then will you move that the meeting be adjourned for three months?

Mr. Adams: That had better be left.

A vote of thanks was then passed to the chairman, who in reply expressed his acknowledgments, and hoped the Board would hereafter be able to lay something better before them.

FAURE ELECTRIC ACCUMULATOR COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Monday last at the Cannon-street Hotel, Sir A. J. Otway, Bart., M.P., the chairman, presiding.

The Secretary (Mr. Herbert Canning) having read the notice convening the meeting,

The Chairman said: Gentlemen, you have heard the notice read convening this meeting. You are aware, therefore, of the object for which you are called together to-day. It is to formally confirm the resolution which was passed, I think with unanimity, on the last occasion on which we met. Subsequently a notice has been issued stating that possibly I might not be able to take the chair before two o'clock, and this was done to enable those who were interested in the Company to attend, as possibly statements of importance for the Company might be made. Well, that seems to me really to be the point that most interests us to-day. The confirmation of this resolution, I believe, will be a mere formal matter, and I dare say those who approved of it on the first occasion will not have altered their opinion now. Indeed, it seems to me to be the just and proper arrangement, and I am not the least surprised that you adopted it with unanimity. In regard to the statement I have to submit to you to-day I shall ask your very serious attention. I think I have said before that I always considered in all matters of business the straightforward and the most outspoken course was that which should be always taken between directors and shareholders. I do not understand any other way of conducting these matters myself, and I hope I never shall understand any other way. There may be some who are cleverer, but this seems to be the proper course to take, and I shall not depart from it. Therefore, I consider when directors have decided upon any course of action which may affect seriously the prospects of the Company, it is their duty to take the earliest opportunity to make that decision known to the shareholders. I think it almost disingenuous, and I doubt whether it would be fair to meet a body of gentlemen to discuss a formal resolution when we have an opportunity of speaking to you, and to go away without having said that which was uppermost in our minds. Therefore, I make no apology for the communication of the statement which will be made to you to-day. I will try to make it—as much as possible at any rate—intelligible and clear. Now, gentlemen, you the other day, with unanimity—with unanimity I must beg to observe—approved of the project of M. Philippart with regard to the conduct of the proceedings of this Company, and I must be allowed to say, in passing, that I recognise M. Philippart as a man of remarkable ability and of very special knowledge with regard to the accumulator, and, therefore, my impression is that in the matter he undertakes he will act for the advantage of the Company. There is every reason to hope in this case he will succeed; and if he does succeed great advantage may accrue to the concern. But, gentlemen, I am sure you will forgive me if, while saying this, I should also state that it is almost the unanimous opinion of the Board—at any rate there are those present who will be able to correct me if I am wrong—that there is one mode of conducting business that is more desirable in our view than any other. For instance I considered that if the making of the accumulator was to be done in England, and the business to be carried on in this country, it was essential that the directors of the Company should be English. On the other hand, if the making of the accumulator is no longer to be carried on in England, and the business is to be transferred to another country, then I am unable to say that English directors are the most suitable, and I am not able, neither are any of your directors able, I presume, to conduct the affairs of a company the whole of whose interest and business is in another country. Therefore, this brings me to the conclusion as to what shall be the order of our proceedings in future, and I am bound to say that in this opinion I find myself in accord with every member of the Board. I have the opinion that it would not be necessary for us, and I doubt even if we should be the most proper persons, under the circumstances to conduct this Company. I may say, speaking for myself, and I think I am speaking for my colleagues, that they have every desire to give effect to the unanimous wish or the unanimous opinion as expressed at the meeting on the occasion to which I have referred, but we do not find ourselves able to agree with the mode by which it was proposed to carry into effect the resolution then passed. Now, I do not wish to say one word against it—not a word. I think that M. Philippart will carry out what he has commenced according to his fashion, and according to the customs especially of France, but the mode of procedure does not commend itself to us. I have not been, and I am not aware that any of my colleagues have been, connected with financial operations. We consider this Company more as an industrial than a financial one, and the proposed method of procedure did not seem to correspond to our opinion of the way this business should be conducted. Therefore we came to the conclusion that the best thing to do under the circumstances was that when the new mode of procedure came to be carried into effect we should not be the persons to give effect to it. It would be better that the direction should be composed of gentlemen entirely in accord with M. Philippart and with his views. Well, we should prefer, after having come to that conclusion, that we should in the ordinary course of things have selected, or, rather, ask you to select, some gentlemen to take our places at once, but we remembered we had what we considered an obligation to discharge towards the shareholders—viz., that M. Philippart undertook, or rather the Société la Force et la Lumiere undertook through him, to give to every shareholder of this Company one fully paid-up share of the Faure Accumulator Company for two shares partly paid up which he might hold in the Company at the present moment, conferring upon him that which we considered an undoubted benefit, by relieving him of all future liability in regard to these shares—until that obligation, or undertaking, is carried out, I think we can quite well administer the affairs of the Company, and we should remain. It seemed to me right and proper, and, indeed, it seemed to be our duty to remain to see that that obligation was fulfilled. The fulfilment of that obligation does not take place till the 1st January, unless M. Philippart should previously determine it. He has until the 1st January to fulfil that obligation, and therefore we shall consider it our duty to remain in the position we are in until the 1st January, unless, as I said, the shares are previously delivered. Afterwards there is really, in my opinion, no necessity whatever that we should continue, indeed I think it would be for the advantage of the shareholders, if M. Philippart's scheme is carried out, that he should have, as I said before, gentlemen associated with him who are entirely in accord with him. I repeat once more, there is no misunderstanding, and I do not want to say a word against M. Philippart's mode of carrying his scheme into execution, or as to his skill and capacity. I believe he will tell you presently how the matter stands. There will be a pecuniary advantage to this Company, no doubt, but it is not on the lines altogether on which this Company was formed, and on which we assumed the direction. I trust, therefore, that you will think we have acted in a manner which was right and proper, and one consistent with our statements and in accordance with our obligations to you, if when the moment comes we ask you to relieve us of any further responsibility in the matter. Now, what I wish to put before you will be, first of all, this resolution, and then I think it will be interesting to all the shareholders, as M. Philippart is present, that he should make his statement to you. His interests are large. He is here to address you, and I think it will be interesting to you to hear what he has to say. I have, therefore, to ask you to confirm the resolution passed at the meeting of the 6th November last, which is as follows:—"That the scale of voting by the shareholders, as at present prescribed by Clause 64 in the Articles of Association of the Faure Company be altered, and that a clause be substituted in lieu thereof in the following terms:—'That on every question to be decided by a poll every member present, in person or by proxy, shall have one vote for every Ordinary share up to ten inclusive, and he shall have an additional vote for every five shares beyond the first ten Ordinary shares up to 100 inclusive, and an additional vote for every ten Ordinary shares beyond the first 100 shares; and the holder of every ten Deferred shares shall have the same number of votes in respect thereof, as if they were one Ordinary share, every ten Deferred shares being, for the purposes of voting, always equivalent to one Ordinary share. No member shall have more than 500 votes in all, and no member shall be entitled to vote on a poll as the holder of any shares in respect of which he shall not have been registered for three calendar months previous to the meeting.'"

Mr. W. Lean seconded the resolution, which was put to the meeting, and carried unanimously.

The Chairman: Now, gentlemen, I shall be prepared to hear the observations of any gentleman present, and perhaps it may be better if I ask M. Philippart to make any statement he has to submit.

M. Philippart (who spoke in French, Mr. Campbell officiating as translator) said that since the last meeting he had been making the necessary arrangements in order to carry out the scheme which he had laid before them. He thought it was almost settled, except the affixing to it the necessary signatures. The first thing he gave his attention to was that the Storage Company should give back to the Faure Company the 20,000 shares they held in the Faure Company upon certain terms and

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conditions. The shares which the Storage Company possessed in the Faure Company were a burden for the latter and a considerable danger and difficulty if the Company ever came into liquidation from one cause or another. He did not express an opinion as to whether the Faure Company would have had to go into liquidation, but if it had continued to go on without some change in its programme he thought it might have been possible. His endeavour had been to change the whole current of the affairs of the Company, and to put it on a different basis. He thought an arrangement of this kind would be carried out—that the Faure Company should cede to the Storage Company the remainder of their English patents, the Storage Company giving back to the Faure Company the shares which they held in it, allowing the Faure Company to retain the shares which they held in the Storage Company. The result would be that if the Faure Company did go into liquidation with the funds they had remaining in their hands and the value of the shares they held in the Storage Company they would have something like £50,000 to the good. He had the greatest opinion of the Faure accumulator, and also of the Sellon-Volckmar accumulator, and he considered these the only accumulators which were of any value. He looked to a prosperous future for the Company. He had the greatest opinion of this question of electricity, but he thought that, whatever was made in England, a very much larger profit must, as a matter of course, be made upon the Continent. He considered, however, that in France alone the question of electricity was worth all the other countries on the Continent together. By arrangements which he had made he was the possessor of the patent for France and the French colonies. By these contracts becoming definite, and by this Company giving these up, they became proprietors of something like 92 per cent. of the whole patents in France for France and the colonies. He had great hopes for the future, and he reminded the meeting that he and his friends were proprietors of the largest portion of this concern. He hoped that by the end of March the shareholders would receive back a sum equal to the amount of money which they had put into the Faure Company, and they would possess beyond that a share of equal amount in the French Company—the owner of all the French patents. Whether they paid £2 per share, or whether they paid £10, they would get the whole of the money back which they had paid into the Faure Company, besides being possessors of a share of equal value in the company owning all the French patents. He could quite enter into the feelings of the directors when they said that the undertaking would be more French than English, and he agreed that the majority of the directors should be French; but he did not see why some of the gentlemen on the present Board should not remain. That was a question, however, which he could not, of course, decide for them.

In answer to a shareholder,

M. PHILIPPART said the Faure Company would not cease to exist unless the whole of the money the shareholders had paid in was given back, at the same time allowing them to hold shares of equal value in the French Company, in which case the remainder of the Faure Company's English patents would go to the Storage Company.

The CHAIRMAN, in reply to a further question, said the interests of the shareholders would then be transferred from the English to the French Company.

A SHAREHOLDER asked whether the shares given them in the French Company would be fully paid up?

M. PHILIPPART (through Mr. Campbell) replied in the affirmative, and said, in answer to a further question as to whether, in the event of all the shareholders not accepting the offer made to them, the Faure Company would be wound up, that the decision would lie with the majority of the shareholders.

After some further discussion,

The CHAIRMAN said he could not admit that there was any foundation for M. Philippart's remark that this Company might have gone into liquidation if the directors had continued to conduct its affairs on the lines they had hitherto done. He considered this observation was unjust to his colleagues. Most of the shareholders were men of business, and were, therefore, aware that in the case of a new invention much had to be done to make it known, and in the way of experiments, so that a large return could not be expected from the investment at the commencement. He contended, and should always contend, that the concern had been going on very favourably, making such progress as was consistent with new inventions of a complicated character. He had not, he was sure, said a word which could be considered hostile to M. Philippart. He had always acknowledged his capacity, but these were not schemes which had his concurrence, or which the present Board would like to enter upon. At the same time he had faith in M. Philippart's ability and knowledge of the accumulator, and it would be very gratifying to him as a shareholder if his (M. Philippart's) scheme were successful.

On the proposition of Mr. LEAN, a vote of thanks was passed to the chairman and directors for the manner in which they had conducted the business of the Company, and the proceedings terminated.

THE ORIENTAL TELEPHONE COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Monday, at the offices, 3, Great Winchester-street Buildings, E.C., Colonel Gouraud in the chair.

Mr. W. G. HALL (the secretary) read the notice convening the meeting, and the minutes of the previous meeting were also read and signed by the chairman as correctly entered.

The CHAIRMAN said: Well, gentlemen, I have the pleasure to propose for your approval the motion which you have heard read, and submit it for your confirmation. There is very little to say about this matter. But for the fact that the meeting is for the simple purpose of confirming the resolution previously passed by a very large meeting of the proprietors, it would be matter of regret that there are so few shareholders here to-day. Probably there would have been more here to-day had it not been for the very noted occasion which has occupied so many of Her Majesty's subjects in paying their customary tribute of loyalty. I am sure we should all like to be there, too, if we had good places. It is also to be noted that Her Majesty has on this day the usual Queen's weather, and I hope, and we may all hope, that it will prove an auspicious circumstance in the history of our own affairs. The number of proxies represent a very large proportion of the capital, more than 50,000 shares having been sent in. I beg to move the confirmation of the following resolution, viz.:—

That the clause or sub-section marked (*c*) contained in the 60th of the Company's Articles of Association be repealed, and that, in lieu thereof, the following shall henceforth stand and be the clause or sub-section marked (*c*) contained in the said 60th Article; that is to say:—

"(c) They may of their own authority sell all, or any part of the business, goodwill, patents or patent rights, and property of the Company, or the business, goodwill, patents or patent rights, and property appropriated for, or appertaining to, any branch of the Company's business, either wholly or partially, for cash or for shares, debentures or other interests in any company or corporation, or to any person or persons; and if deemed expedient, the directors may hold or (so that the capital of the Company be not thereby reduced) distribute in specie among the members in proportion to their holdings, or otherwise deal with such shares, debentures, or other interests."

Mr. P. CARNEGY: I have the pleasure to second that resolution.

The resolution was then put to the meeting, and carried unanimously.

A vote of thanks to the chairman terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Dec. 6.		Business Done Week Ending Dec. 6. Highest.		Lowest.	
Anglo-American	47½,	48½	.....	47¾	.....	47½
Do. Preferred	78,	79	.....	77¾	.....	77½
Do. Deferred	17½,	18½	.....	17¾	.....	17½
Brazil Submarine	11⅝,	11¾	.....	11¾	.....	11⅝
Cuba	9½,	10	.....	—	.....	—
Do. Preference	16,	17	.....	—	.....	—
Direct Spanish	7,	7½	.....	7½	.....	7½
Do. Preference	16,	17	.....	—	.....	—
Direct United States Cable	11¼,	11¾	.....	11¾	.....	11 3-16
Eastern Telegraph	10⅝,	10¾	.....	10¾	.....	10⅝
Do. 6 per Cent. Preference	13,	13½	.....	13½	.....	13 3-16
Do. 5 per Cent. Debentures, 1899	103,	106	.....	—	.....	—
Eastern Extension	11¾,	12⅛	.....	12⅛	.....	12
German Union	10,	10½	.....	—	.....	—
Globe Telegraph and Trust Company.	6⅜,	6⅝	.....	6½	.....	6⅜
Do. Preference	12⅜,	12⅝	.....	12⅝	.....	12⅜
Great Northern	12⅜,	12½	.....	12⅝	.....	12⅜
Indo-European	31,	32	.....	31½	.....	30½
Mediterranean Extension	1⅜,	2	.....	—	.....	—
Do. Preference	6,	8	.....	—	.....	—
Reuter's	12½,	12½	.....	12	.....	12
Submarine	250,	255	.....	252	.....	252
West India and Panama	1⅜,	1⅝	.....	1 5-16	.....	1⅛
Do. 1st Preference	6½,	7	.....	7	.....	6⅝
Western Brazilian	7⅜,	8	.....	7 15-16	.....	7⅜
West. Union 7 per Cent. 1st Mortgage	122,	126	.....	122	.....	122
Do. 6 per Cent. Sterling Bonds	102,	105	.....	—	.....	—

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¼	.....	1 1-16	.....	1 11-16
Oriental	⅛,	¼	.....	¼	.....	¼
United Telephone	10½,	11½	.....	11	.....	11

ELECTRIC LIGHT.

Anglo-American Brush	8¾,	9¼	.....	9¼	.....	8 11-16
Brush Light (£4 paid)	9,	—	.....	—	.....	—
Do. (fully paid)	18,	19	.....	—	.....	—
Hammond Light	5,	—	.....	—	.....	—
Eastern Electric	2,	2½	.....	2½	.....	2
Great Western	¼,	½	.....	—	.....	—
Midland	¼,	½	.....	—	.....	—
Scotch	½,	1	.....	—	.....	—
Swan	1½,	2½	.....	—	.....	—
Gülcher	1½,	1⅝	.....	—	.....	—
Pilsen	1½,	1½	.....	—	.....	—
Maxim-Weston	7-16,	9-16	.....	½	.....	½
Indian and O. Storage	1,	1⅛	.....	—	.....	—

TRAFFIC RECEIPTS FOR NOVEMBER, 1882.

Companies.	Nov., 1882.	Nov., 1881.	Increse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	1,800	2,439	—	639
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	54,093	49,829	4,263	—
Great Northern Telegraph Company	20,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SPAIN.—The cable between Marseilles and Barcelona is interrupted.

THE TELEPHONE IN QUEBEC.—A telephone cable has been laid between Levis and Quebec at Victoria Cove.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY. — The traffic receipts of this company for the week ended December 8 were £3,830.

THE TELEPHONE IN FRANCE.—It is said that all French barracks, in places where there are several, are to be connected by means of telephone lines.

GERMAN PATENTS.—Between May and October in this year 190 patents for inventions connected with the applications of electricity were granted in Germany.

PARA.—The cable between Fortaleza and Maranham is interrupted, and there is therefore at present no telegraphic communication between Maranham and Para.

BRITISH ALMANAC AND COMPANION.—The fifty-fifth issue of this almanac, which has just appeared, contains an article on "Electric Lighting," written by Mr. L. T. Thorne.

ELECTRIC TRAMWAY FOR SAN FRANCISCO.—Rumour says that electric motors are about to be introduced on the San Francisco street tramways. The current will be supplied by accumulators.

BRITISH GUIANA.—It is stated that telegrams are received in British Guiana in 52 minutes after leaving London, which is quick work, considering the number of stations they have to pass through.

THE EDISON SYSTEM IN SAN FRANCISCO.—The Edison Electric Light Company, of San Francisco, has been formed with a capital of 5,000,000dols, of which 3,500,000dols. was taken before the public announcement was made.

WEST INDIES AND BRITISH GUIANA.—The cables between Trinidad and Demerara, and between St. Croix and Trinidad, being now repaired, telegraphic communication is restored to all parts of the West Indies and British Guiana.

THE WESTERN UNION TELEGRAPH COMPANY. — A despatch from New York, dated Wednesday night, says:—"The surplus of the Western Union Telegraph Company, after payment of the quarterly dividend of 1½ per cent., is 3,490,447 dollars."

NOTTINGHAM TELEPHONE EXCHANGE.—The number of messages transmitted through the National Telephone Company's Exchange at Nottingham for the week ending December 7 amounted to 5,137, being an increase of 4,500 on the corresponding week in 1881.

ELECTRIC LIGHT IN NEW ZEALAND.—Preparations are being made to light the house of Sir F. D. Bell's Stag Valley Estate with the electric light, the power being supplied by a large waterwheel, from which insulated wires are to run to the residence in question.—*Colonies and India.*

ELECTRIC LIGHTING FOR GRAVESEND.—The Gravesend Town Council, instead of applying for a provisional order, have appointed a committee to confer with the South-Eastern Brush Electric Light Company on the subject of introducing the light into the town. This company, we may add, has applied for an order.

ELECTRIC LIGHT IN LONDON.—The Civil Service Supply Association, in Bedford-street, Strand, W.C., have adopted several Brockie lamps for lighting their building. The lamps outside the building give a very good light. They have been erected by the British Electric Light Company. The current is generated by Gramme machines.

THE TELEPHONE IN COLOMBIA.—The Colombia and Venezuela Telephone Company has been registered in the office of the clerk of Monmouth County, New Jersey, U.S.A. The company has a capital of 100,000 dollars, and will construct, maintain, and operate telephone lines in the United States of Colombia and Venezuela. The main office is at Longbranch.

ELECTRIC LIGHT AT SALTLEY.—With reference to our note of last week under this head, the manager of the Birmingham and Warwickshire Brush Electric Light Company writes to say that the installation at Messrs. Brown, Marshall and Co.'s works was completed some time since. It consists of 40 Brush lamps, driven by a 16 horse-power Fowler semi-portable engine.

CRYSTAL PALACE EXHIBITION.—The combined Electric and Gas Exhibition was opened at the Crystal Palace on Wednesday last by the Lord Mayor. At present, as usual with exhibitions, things are in a backward state. No doubt, however, exhibitors will push matters forward now, and we shall hope to be able to give a better account of the exhibition in a week or two's time.

EARTH CURRENTS AND SUNSPOTS.—On the 1st of September, 1859, two astronomers, Messrs. Carrington and Hodgson, who were observing a spot on the sun's disc, noticed a star of light break from the spot and move across the sun's surface. On referring to Kew Observatory subsequently they found that at this particular moment the magnet there had recorded a magnetic disturbance.

A HAZY NOTION OF EARTH CURRENTS.—A broker's office in Wall-street, New York, having a leased wire, sent up a message to 195 on the morning of the big electrical storm to know what was the matter with their wire. Chief Operator Bogart replied that the "aurora" was on it. The firm thereupon telegraphed back to have it cleared off immediately, as they wanted to use the wire.—*Operator.*

PATENT DISCLAIMER.—Notice has been given by Mr. St. George Lane-Fox and the Anglo-American Brush Electric Light Corporation of their intention to file a disclaimer of certain parts of Mr. Lane-Fox's patent, dated 9th October, 1878, No. 3,988, which relates to "Improvements in obtaining light by electricity, and in distributing and regulating the electric current for the same." &c.

ELECTRIC LIGHT IN PRINTING WORKS.—A few days since we noticed that the printing works of Messrs. Hazell, Watson, and Viney, at Aylesbury, were to be lighted throughout by the Provincial Brush Electric Light Company. The lights, Brush arc lamps, were started on Tuesday night. The light was very much appreciated by the printers, and they are unanimous in praise of it, preferring it greatly to gas.

ELECTRIC LIGHTING AT LIVERPOOL DOCKS.—The electric light at the new northern docks, which were formally opened by the Prince of Wales in September last year, has given such satisfaction that an order has been given to extend it so as to light another 200 acres of ground. The work is being executed by the Electric Lighting Supply and Fitting Company, of Victoria Mansions, who designed and carried out the original installation.

ELECTRIC LIGHTING FOR CAMBRIDGE.—The Cambridge Improvement Commissioners have been recommended by their Electric Light Committee not to proceed any further in the matter of obtaining a provisional order, but to content themselves with giving instructions to their officials to see that protective clauses are inserted in any order that may be

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granted to the Provincial Brush Electric Light Company to supply electricity and light in that town.

Electric Lighting at Manchester.—The Manchester Royal Exchange was illuminated on the night of the 1st December for the first time by the British Electric Light Company, who have secured the contract, with 10 automatic Brockie arc lights of 3,000 candle-power each and 400 British incandescent lamps of 15 candle-power each. The light attracted a great many sightseers and was universally admired. The arc lights will ultimately be increased to 17.

Electric Lighting and Fire Insurance Companies.—The offices of the Eastern Electric Light and Power Company and the Indian and Oriental Electrical Storage and Works Company at Winchester House, Old Broad-street, E.C., have for some time past been lighted by incandescent lamps fed by Sellon-Volckmar accumulators. We are informed that two fire insurance companies have inspected the system, and have duly recognised it in their books without any additional charge being made.

Edinburgh Telephonic Exchange.—During last week upwards of 7,554 calls from subscribers were registered at the switching offices of this Exchange. The week previous showed a total of only 4,992 calls. These facts go to prove the rapid advance which the telephone is now making as a medium of conducting business in the present inclement weather. The luxury thus afforded of carrying on every day work without exposing oneself to the difficulties of locomotion is evidently very largely taken advantage of.

The Detection of Metallic Masses in the Human Body.—We have been favoured by Professor A. Graham Bell with advanced proofs of his paper on this subject, read at the late meeting of the American Association for the Advancement of Science. A short abstract of this paper was given at the time of the meeting. It is possible that we may be able to find the space necessary to give the whole paper, which cannot but be interesting not only to professional electricians, but to surgeons and soldiers.

Extension of the Telegraph in the North.—A meeting of farmers was held on Wednesday week at Fortingall, Perthshire, in connection with the establishment of a telegraph line between Aberfeldy, Fortingall, and the district of Glenlyon. Sir Donald Currie, M.P., was present, and explained the arrangements which he had made with the Government in the matter. The meeting decided to take steps to complete the guarantee fund, and Sir Donald Currie was authorised to conclude the terms with the Government.

Electric Lighting in Newcastle-on-Tyne.—Messrs. James Coxon and Co., drapers, of Newcastle-on-Tyne, have successfully introduced incandescent lighting into their shop. Their windows are lighted by Swan lamps of 50 candle-power, and the shops and show rooms by the ordinary Swan lamps of 20 candle-power. The *employés* of this firm have, doubtless, learnt to appreciate the pure atmosphere afforded when incandescent lighting is employed in place of gas. The absence of steamy windows during this cold weather must also be a pleasantly obtrusive fact.

Storing Electricity.—This is the title of an article in this month's *Harper's Magazine*. The writer gives a brief exposition of the storage of energy, utilising the well-worn water analogy for his purpose. He then describes the experiments of Gautherot, Ritter, Grove, and Planté, illustrating Grove's gas battery and Planté's secondary battery. He concludes by a description of Faure's modification of the Planté cell. The more recent labours of Sellon and Volckmar, Sutton, and others are not mentioned. Perhaps some hypercritical electricians may object to the title "Storing Electricity." We have heard it said that electricity cannot be stored, though electrical energy may.

Electric Light on Shipboard.—The United Steamship Company's steamer "Kjobenhavn" has just been lighted with incandescent lamps by the British Electric Light Company. The lamps have been tastefully arranged throughout the ship, and fitted on bronze gilt brackets representing mermaids. The lights have been running now for nearly two months, and have given great satisfaction. One arc light is used on board. It is probable that other vessels of the same line will be lighted by the same system. The British Indian Steam Navigation Company's "Dacca" is to be lighted by means of 108 British incandescent lamps and two arc lamps, supplied and set up by the British Electric Light Company.

Severe Thunderstorm in Orkney.—Reports from Kirkwall, dated December 11, speak of a severe thunderstorm which passed over the Orkneys on the previous night, severely wounding five people and killing four cattle. The storm came on shortly before six o'clock, and continued for some time. As Mr. William Hepburn, wife, and family were sitting at the fire a flash came down the chimney, and struck the whole five. Mrs. Hepburn was struck behind the ear, her ear being laid open on her cheek; her husband was severely struck from the abdomen down. Miss Hepburn, her brother, who was married, and his little boy were also struck. Some of them had their clothes burnt. Grave fears are entertained for the recovery of the old people.

Underground Wires in America.—The Brooks Telegraph Company of New York intend to grant licenses to subcompanies to lay underground wires in the different cities of America. It is authoritatively stated that the Western Union Company will lease from these companies such wires as they need, instead of laying a system for themselves. The Western Union Company cannot afford, it is said, to change from the overhead system and pay dividends at the same time unless the expense is thus divided with all others interested. Such a license has already been granted to certain gentlemen to lay 5,000 miles of wire in Philadelphia, underground, within two years, provided they obtain proper facilities for doing so from City Councils, and, if laid, the wires will be open to the use of any corporation willing to pay rental for them.

Electric Lighting at Danzig.—A correspondent writes:—"A number of experiments were made yesterday (Dec. 5) at the office of Herr Von Assman, who is the chief engineer of the marine works at the German Imperial Docks here (Danzig). The intensity of various gas burners was measured by means of a Bunsen photometer. The ordinary Danzig gas burner was found to give only about six candles. The Edison light, when measured, gave a light equal to 17 standard candles. An opal shade was then put over the light, and the intensity was reduced to about eight candles, thus showing a loss of about 55 per cent., when a ground glass globe is used the loss is about 20 per cent. The Edison light is used here to light up the machine works, as they work till ten o'clock every evening. A and B lamps are used, and the workmen are well satisfied with the light."

Electric Light on the "Himalaya."—The first complete installation of incandescent lamps in the Royal Navy has been just submitted for trial on board H.M. troopship "Himalaya" at Devonport Dockyard, where, for nearly two years, she has been undergoing complete renovation. A contractor's run was made on Wednesday last before the officials of the Admiralty, when extremely satisfactory results were obtained both as to working of machines and engines, which are of the Siemens-Brotherhood type, and as to the illumina-

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tion afforded. The installation has been effected by the Swan United Electric Light Company, and about 170 lamps of 20 candles each and 60 lamps of 10 candles each have been employed, which are destined entirely to replace all other means of lighting. The utmost care has been taken to ensure perfect insulation of the leads and durability and strength in the fittings. The work has been carried out by Mr. J. F. Albright, engineer to the company.

Summer Telegraph Offices in Germany.—The Berlin correspondent of *The Times*, telegraphing on Wednesday, says:—"Some interesting statistics have just been issued as to the experiment tried this year of establishing summer post and telegraph offices on mountain peaks, and other remote and solitary spots much visited by tourists. The result has been such as to encourage a repetition of the practice. In all, 103,585 letters and 8,064 telegrams were thus forwarded; more than 23,000 of the former alone having been despatched from the Bastei, a lofty precipice in the Saxon Switzerland. From the Wartburg, in Thuringia, 20,000 letters have been sent, and an equal number from the Schneekoppe, in the Giant Mountains, from the Brocken, in the Harz, 16,000, and so on. From the Brocken and the Schneekoppe were sent 1,576 and 1,279 telegrams respectively. The inventiveness of Dr. Stephan, the Postmaster-General of the Empire, is notorious. Several bodies of officials from St. Martin's-le-Grand have come over to Berlin within the last year or two to study the working of the General Post Office, an institution in which the most captious foreigner could find little to criticise."

Protection against Lightning.—The Pic du Midi Observatory, recently established in the Pyrenees, is of necessity greatly exposed to thunderstorms. In consequence considerable care has been taken to protect it against the effects of lightning. Two lightning conductors about 8ft. high have been fixed at the two ends of the house, and connected together by an iron armature, as also with all the ironwork of the building, and with thistle-headed metallic spikes having six points at the angles of the roof and on the shed. It was found advantageous to make the points truncated cones, instead of sharp; they are of gold-plated copper, with tin junctions. These points remain intact, while sharp ones are damaged. The whole system is connected with two other large conductors, 233ft. apart, on two small eminences a little way from the house, and connected by chains, the one with the Lac d'Ouest, the other with a snowy ravine. The arrangement works perfectly; a hissing sound is often perceptible during thunderstorms, and it seems as though the storm is of diminished intensity at that point. It is said that the telegraph clerk at Bagnères, however, has often to use his lightning conductor to avoid being struck. The observatory is situate at between 9,350 and 9,400 feet above the sea (2,877 metres).

Electric Lighting and Gas.—In the course of a discussion on a recent paper read by Mr. C. J. Woodbury, before the New England (U.S.A.) Cotton Manufacturers' Association, which we have alluded to in another note, Mr. C. W. Lippitt, of Woonsocket, Rhode Island, said that the Globe Mills had been supplied with the electric light, and it was much preferred to gas. For the season of 1881 and 1882 the company had used 117 large lights, running them for 367 hours, at an actual cost of 327dols. 83c. Each lamp supplied four looms with light. These took the place of 220 gas burners, which, burning four feet of gas per hour for 367 hours, cost 710dols. 60c. The saving in favour of electric lights was 382dols. 77c., or an actual saving of 57 per cent. In another mill oil gas is used, and although it can be supplied at a lower cost, its results are not so good as coal gas. The cost of running 220 burners of oil gas for 367 hours is 473dols. 11c., which still leaves a margin of 145dols. 28c., or 31 per cent. in favour of the electric light. Mr. Thomas Livermore, of the Amoskeag Mills, said that they had 5,000 looms lighted with 465 electric lights, which had during the last eight months consumed 37,000 carbons. The average cost of each lamp per hour is 2·89c. He had found that one arc lamp could take the place of twelve gas burners, supplying twelve looms with light.

Continuous Lighting for Sixty-four Hours.—During the recent extraordinary fog the Edison Electric Light Company, recognising the necessity for distributing the light to their customers without intermission, maintained their dynamos in action at Holborn-viaduct for a continuous period of sixty-four hours without stopping. Starting at three o'clock on Saturday afternoon, December 9, the dynamos ran without ceasing during Saturday, Sunday, Monday, and Monday night, stopping at eight o'clock on Tuesday morning, December 12. We do not know of any previous continuous, nor, in fact, any similar running to this. The current was supplied from two large dynamos, which are used alternately, and during this long run the current was switched off from one dynamo on to the other, or back again five times by means of a specially designed switch, which enables this to be done without in the least degree interrupting the lighting. The incandescent lamps in the shops on Holborn-viaduct and in the street were thus maintained during the whole of this time. The company has therefore demonstrated not only their ability to supply electric lighting on a large scale, as they have been doing for the past nine months, during the hours of usual darkness, but to maintain constant electrical pressure in the mains day and night, and to comply completely with the condition of continuity of lighting, which is requisite in order that the problem of distributing electricity for lighting and other purposes may be considered solved.

Dynamos.—On Monday night Professor Sylvanus P. Thompson delivered the second of the Cantor Lectures for the session 1882-3, on Dynamo Electric Machinery, at the hall of the Society of Arts, Adelphi. Sir F. Bramwell occupied the chair. Professor Thompson, dealing with the dynamo in practice, said that the first point to consider was the forms of combination used for producing either constant strength in the current or constant electromotive force in the circuit, with the view of rendering the action of the dynamo purely automatic, so that the removal of lamps from one part of the circuit should not in the least affect any other part. Turning to various points in which theory had been put into practice in different descriptions of dynamo electric machines he commented on the forms of the magnets, the pole pieces, the armatures, and the commutators used. He then pointed out the essential difference between a continuous current machine and an alternate current machine, and the peculiar arrangements of the more interesting types, such as those of Edison, Brush, and Gülcher. The distribution of potentiality on the commutators of dynamos he had particularly examined, and had deduced several important consequences with reference to the construction of armatures and field magnets. He observed that science had now advanced so far that it could point out how machines could be constructed with a full knowledge of what their actual performances would be. The subject of the next and concluding lecture is the dynamo as a motor.

Electric Lighting for the City.—On Thursday week a special meeting of the City Commissioners of Sewers was held at the Guildhall, when Mr. Moore again proposed the

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rescinding of two resolutions which had been passed at a previous meeting—viz., "That while the Commission is in favour of electric lighting in the abstract, it is advisable to allow all further experiments to be conducted at the risk of the lighting companies, and not at the expense of the ratepayers;" and, secondly, "That the Remembrancer be instructed to appear on the application of the electric lighting companies and secure clauses protecting public and private rights." This was carried by a small majority, and there then arose a discussion as to the standing orders, by which a two-thirds majority is necessary to revoke a previous motion. The chairman, being at issue with the officers of the Commission and the majority of the Court, had at the last meeting vacated the chair; on Thursday week, after consultation with the Lord Mayor and the Recorder, he returned to his position and declared the motion carried. On the motion of Mr. Stoneham it was then resolved "That, considering the vast interests at stake, a select committee be appointed to inquire into the necessary steps to be taken to enable the commission to become the undertakers for the supply of electricity to the whole or any district of the City of London under the provisions of the Electric Lighting Act, 1882, to report forthwith to the Commission, and that in the meantime the Remembrancer be instructed to oppose all other applications."

Siemens's Selenium Photometer.—The following is a description of a photometer constructed by Messrs. Siemens and Halske, of Berlin. A horizontal copper tube, three centimetres in diameter and 15 centimetres long, is mounted on a stand fixed at one end of a horizontal graduated bar. The stand, with the copper tube attached, is movable about a vertical axis, and is provided with a levelling screw. One end of the tube is fitted with a metal diaphragm having a circular aperture in its centre, and the other with a mounting carrying cross wires. This latter can be removed and replaced by a short horn box containing a plate of selenium specially prepared. The plate is protected from the light by a valve, which can be opened by a button outside the tube. At two opposite points of the plate wires are attached, which connect it through a galvanometer to the battery. A. Thomson portable mirror galvanometer is the best. To take observations, the tube is turned towards the light to be measured, which is then centred by means of the cross wires. The diaphragm and the mounting carrying the cross wires are removed, and the latter replaced by the selenium plate. The circuit is completed, and the plate exposed to the light. After reading the deflection of the galvanometer the tube is turned about its vertical axis until it is in line with the graduated rod. A standard candle slides on the rod, and its distance from the plate is adjusted until the galvanometer deflection is the same as before. The intensity of the lights is then proportional to the squares of their respective distances from the plate.

Electric Lighting in London.—At the last meeting of the Islington Vestry, the Electric Lighting Committee were taxed with a want of knowledge of the subject, and one member very sensibly recommended them to educate themselves a little in this particular direction before they reported on the question. The Clerkenwell Vestry have received a report from their Committee of Works relating to the applications of the following companies to supply electricity in their parish, viz.:—The Metropolitan Brush Electric Lighting Company, The Gülcher Electric Lighting Company, The Edison Electric Lighting Company, The "Pilsen," "Joel," and General Electric Lighting Company; Ferranti, Thompson, Ince, and Company (Limited), and The Maxim Weston Electric Light Company. The committee recommended that the consent of the vestry be given to the applications of the Metropolitan Brush Electric Lighting and Power Company, and the Edison Electric Light Company to the Board of Trade for licenses to light the parish for seven years, subject to the vestry being protected in every respect, and that the liabilities of the companies for repairs of roadways after trench work extend to a period of two years from the date of the work being done. The ratepayers of St. Mary, Newington, S.E., held a meeting last week to protest against the proposed application by the Newington Vestry for a license to supply electricity in the parish. At this meeting a resolution was passed appointing a committee of ratepayers to take steps to oppose the application of the vestry. The St. Pancras Vestry have adopted the report of their Electric Lighting Committee, which recommended them to apply for a provisional order.

Electrical Exhibitions.—This was the subject of a paper read by Mr. W. H. Preece, F.R.S., at the Society of Arts on Wednesday night, Mr. Spottiswoode, P.R.S., in the chair. Mr. Preece's paper was a brief summary of the various exhibitions that have been held since the great exhibition of 1851. The applications of electricity occupied but a small corner at any exhibition until that of 1876. This, however, as far as the public was concerned, was a failure. Its title, "the Special Loan Collection of Scientific Apparatus," was against it, the Press decried it, and, in fact, it fell flat. And yet such priceless treasures as were brought together there will never be collected again. The exhibitions at Paris, the Crystal Palace, and Munich were next alluded to, and the progress indicated at each described. Mr. Preece, in referring to the Congress of 1881, held at Paris, took the opportunity of explaining the various electric units in terms that could be understanded of the people, and advocated the adoption of the metric system. The recent fires that have occurred gave him an opportunity of impressing upon his hearers the capability possessed by electricity in combination with wires, thermometers, and electric bells, of indicating automatically at half a dozen different places the first outbreak of a fire. *En passant*, too, he referred to several photographs which had been taken by Herr Von Zeemssen, a celebrated physiologist of Munich, of an individual who had been involuntarily compelled to assume expressions of various emotions by the application of currents of electricity to various nerves of the face. Mr. Preece's graphic and laughable description of these photos seemed to be appreciated by his audience. The paper will be printed in full in the *Journal of the Society of Arts*. We regret that we have no space for anything but this brief notice.

The Electric Lighting Act.—In the course of his recent presidential address to the Royal Society, Mr. Spottiswoode said that the "Act would have a scientific influence, perhaps, not contemplated by its original promoters. Under this Act, for the first time in the history of the world, energy would come under the grasp of the law, would become the subject of commercial contracts, and be bought and sold as a commodity of everyday use. It was, in fact, far from improbable that the public supply of electricity would be reckoned and charged for in terms of energy itself. But whether this be literally the case or not, a measurement of energy must lie at the root of every scale of charge. Since the Act allowed no restriction to be placed upon the use of the electricity so supplied, it followed that it might be used, and undoubtedly would be used, at the pleasure and convenience of the customer, either for lighting, or for heating, or for

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mechanical, or for chemical purposes. This being so, it was clear that the public must by this process become, practically at least, familiar with the various modes of the transformation of force; and the Act in question might, from this point of view, have been entitled 'An Act for the Better Appreciation of the Transformation of Force.' It had been said, and perhaps with truth, that the electric light would be the light of the rich rather than that of the poor. But in more ways than one electricity might now become the poor man's friend. The advantages in avoidance of heat and of vitiated atmosphere in workshops and factories had often been pointed out, and might ultimately become an important factor in the physical growth and prosperity of our population. But besides this, when electricity was literally brought to our doors, it would become possible, by converting it into motive power of limited extent, to revive some of the small industries which during the last half century have been crushed by the great manufacturing establishments of the country. There were operations capable of being carried out by the wives and families of workmen; there were works of small extent which could be performed more advantageously in a small establishment than in a large one, and it could hardly fail to be a gain to the community if this new departure should give fresh opportunities for the development of our industry in these directions."

Legal.—The case of Phillips *v.* the Great Western Electric Light and Power Company came before Mr. Justice Chitty last week. This was an application by a shareholder of ten shares in the company for the rectification of the register of the company by striking out his name from the list of shareholders. The company was incorporated in March, 1882, with a capital of £125,000, divided into 25,000 shares of £5 each. It was stated in the prospectus that the company had secured a concession from the Anglo-American Brush Electric Light Corporation, under which the exclusive right of use or sale of their dynamo machines and arc lamps, together with an exclusive license to use or sell the Lane-Fox incandescent lamp, was secured to the company for a considerable part of the West of England and South Wales. It was stated on behalf of the applicant that on the 20th of July, 1881, Mr. St. George Lane-Fox assigned to the British Electric Light Company the exclusive right of using and granting licenses to use his inventions in Great Britain and Ireland, and that on the 29th of July, 1881, Mr. St. George Lane-Fox executed a similar assignment to the Anglo-American Brush Electric Light Corporation, subject, nevertheless, to the previous assignment of the 20th of July, 1881. It was contended that the statement in the prospectus with respect to the exclusive right of the company to use or sell the Lane-Fox incandescent lamp in the district named was incorrect. The applicant, without alleging any *mala fides* on the part of the company's promoters and directors, submitted that he was induced by what was, in fact, a false representation to subscribe for the shares in question. — Mr. Waller, Q.C., and Mr. F. T. Procter appeared in support of the application.—Mr. Romer, Q.C., and Mr. Phipson Beale, on behalf of the company, opposed the application on the ground that the mis-statement, if a mis-statement at all, was not material, since the Lane-Fox lamp was the least valuable of the inventions purported to have been conceded to the company by the Anglo-American Corporation.—Mr. Justice Chitty said that, although there was no bad faith, but only some carelessness, imputed to the framers of the prospectus, yet it was plain to an ordinary mind that there had been a mis-statement which was material and calculated to mislead the applicant. His lordship also, without expressing any opinion himself one way or the other as to the value of the Lane-Fox invention, thought that it was not competent for persons who had issued a prospectus which, from beginning to end, had recommended as one of its leading attractions this particular invention to afterwards say, for the purpose of upholding their prospectus, that the invention was of little or no value, and, therefore, not a chief attraction in the prospectus. The application must, therefore, be granted with costs, and the sums paid in respect of the shares returned to the applicant by the company.

Electric Lighting in Mills.—The following is extracted from an account of his inspection of various mills using electric lights, given by Mr. C. J. Woodbury, who is connected with an American insurance company, to the New England Cotton Manufacturers' Association. He first called attention "to the superiority of the electric light over gas, in that it did not vitiate the atmosphere and so impair the health of the workmen. An instance was cited of a basement story of a mill 400ft. by 65ft. and 15ft. high, and containing 456 looms, which was lighted by 457 4-ft. gas burners. It was stated that when the burners were in use the temperature of the room increased 25 degrees in an hour. The gas burners were then replaced by 35 electric lights, and no increase of temperature is noticed. Another advantage of the electric light in mill work is the facility which it affords the operators to distinguish colours and different tints of the same colour at night. In some departments this is of the greatest importance, as the inability to distinguish colours would limit the work to the hours of sunlight. Moreover, it is claimed that the improved illumination obtained by electricity effects a saving, because the proportion of damaged goods usually made when the mill is poorly lighted is thereby diminished. The majority of mills are lighted with gas made by the destructive distillation of petroleum, and of about 80 candle-power, which is generally reduced to 60 candle-power by mixing air with it. The annual cost of oil gas per burner is from 75c. to 1·00dol. In all these estimates interest at six per cent. forms one item in cost. One large corporation, with exceptional privileges, makes its coal gas at an annual cost of 69c. per burner. Another corporation, inland, makes its gas at an annual cost of 1·79dol. per burner. Of two large mills in the same city, manufacturing similar goods, the more modern one makes oil gas at an annual cost of 79c. per burner, while the older one buys coal gas at 2·65dols. per burner. The longer time light is required, the average cost is lessened, because with the addition of operating expenses, the interest on plant, being a fixed amount, becomes a smaller proportion of the whole cost. A dark mill, that is, one of which the interior walls are not whitened, requires about twice the number of lights that are sufficient in a white mill, and uses light about 100 hours a year more than a white mill. The cost of arc lights in several steam mills running 400 hours per year is 6⅔c. per hour, of which 1½c. is for carbons and 5c. for attendance, coal, depreciation, and interest. In a weave room, on very fine work, 24 arc lights replaced 292 6-foot gas burners, which consume 1,752 feet per hour, so one arc light represents the consumption of 73 feet of gas per hour. A careful estimate shows these arc lights to be costing 6½c. an hour, so this arc lighting system represents gas at 89c. per 1,000. A similar estimate in another mill gives the annual cost of gas 21·88dols, and electricity at 11·25dols., or equal to gas at 90c. per 1,000." We may remark that these figures would be much more valuable if they mentioned what system of electric lighting was employed.

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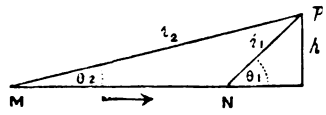
MAGNETIC FORCE OF RETURN CURRENT THROUGH THE EARTH, AND ALLIED MATTER.

BY OLIVER HEAVISIDE.

The magnetic force of a current system can only be completely known when the current is everywhere known (or equivalent information must be given), and no part of the system can in strictness be neglected. If, then, the circuit of a linear current is completed through the earth, the earth-current itself contributes something to the magnetic force. This, as will be seen, is quite a small matter; yet its investigation is both interesting in itself as affording an excellent example of the relations between current, its vector-potential and magnetic force, and on account of a current-sheet analogue that presents itself.

The magnetic force of a straight current C at distance h from the axis is $\frac{2C}{h}$ perpendicular to the plane containing h and the axis, provided the point chosen be not near the ends of the wire, nor at a very great distance from the wire. But in our present case we shall require the correction for the ends.

Let M N be the wire, the current C going from M to N; and let P be any point distant r_1 from N and r_2 from M and



h from the axis or its continuation. Let θ_1 and θ_2 be the angles r_1 and r_2 make with the axis. Then the magnetic force at P of the wire current alone (vector-potential of curl of current) is

$$\frac{C}{h}(\cos\theta_2 - \cos\theta_1) = \frac{C}{h}(1 - \cos\theta_1) - \frac{C}{h}(1 - \cos\theta_2) \quad \ldots \quad (1)$$

and its direction is perpendicular to r_1, r_2, and h. If the diagram has not been perverted, the direction at P will be upwards from the paper. When the point P is near the wire, but not near the ends, we may put $\theta_1 = +\pi$, $\theta_2 = 0$, and we obtain the former expression $\frac{2C}{h}$. Confining ourselves to the neighbourhood of one end, say N, we may put $\theta_2 = 0$; consequently the magnetic force is

$$\frac{C}{h}(1 - \cos\theta_1) \quad . \quad . \quad . \quad . \quad . \quad (2).$$

Just over the end, $\theta_1 = \frac{\pi}{2}$, and the force is $\frac{C}{h}$ only; and along the continuation of the wire it is 0.

Now, although the expression (1) is the vector-potential of the curl of the wire current only, it is also the complete magnetic force of the closed circuit which would be formed by immersing the ends of the wire in an infinitely extended conducting medium, so that the current C leaving N spread out uniformly, the tubes of flow afterwards bending round and finally converging uniformly to M. *I.e.*, (1) expresses the magnetic force of the straight current, together with a radial current of strength $\frac{C}{4\pi r_1^2}$ parallel to r_1, and of another of strength $-\frac{C}{4\pi r_2^2}$ parallel to r_2.

For consider the first mentioned radial current. Its three components are

$$u = \frac{Cx}{4\pi r_1^3}; \qquad v = \frac{Cy}{4\pi r_1^3}; \qquad w = \frac{Cz}{4\pi r_1^3};$$

if x, y, z are the components of r_1. The x-component of the curl is, (Theorem II., p. 56)

$$\frac{dw}{dy} - \frac{dv}{dz} = \frac{C}{4\pi}\left\{z\frac{d}{dy}\left(\frac{1}{r^3}\right) - y\frac{d}{dz}\left(\frac{1}{r^3}\right)\right\} = 0;$$

and similarly the y and z components are *nil*, therefore the curl of the radial current is *nil*, and likewise the vector-potential of the curl; hence the radial currents contribute nothing to the magnetic force.

[Any radial function has no curl. For, let $f(r)$ parallel to r be such a function, then $f(r)\frac{x}{r}, f(r)\frac{y}{r}, f(r)\frac{z}{r}$, are its components, and the x-component of its curl is

$$f(r)\left(z\frac{dr^{-1}}{dy} - y\frac{dr^{-1}}{dz}\right) + \frac{1}{r}f'(r)\left(z\frac{dr}{dy} - y\frac{dr}{dz}\right) = 0.\Big]$$

But in the actual case of return through earth the diffusion is one-sided only. The curl of current within the earth is *nil*, as before, but since there is now a bounding surface, and consequently surface-curl, the earth current does give rise to magnetic force. If D is the surface curl, its strength is $\frac{C}{2\pi a^2}$ at distance a from the electrode (meaning the point N on the earth's surface), and its direction is perpendicular to a (see p. 8). *I.e.*, the lines of surface-curl are concentric circles drawn upon the earth's surface, centred at the electrode. The vector-potential of D is the magnetic force of the earth current. Calling it B, since D has no vertical component, neither has B; and evidently B has the same value and direction at two corresponding points above and below the surface (one being the image of the other). From the symmetry about the electrode, we see that the lines of magnetic force are circles in planes parallel to the earth's surface, and centred upon the vertical axis through the electrode. As we recede from the latter, the strength of force rapidly diminishes.

The strength of force may be determined indirectly thus:—Let us denote by C_1 the uniformly-diffused radial current of strength $\frac{C}{4\pi r_1^2}$. If to this we add another radial current of the same strength everywhere as C_1, but directed *to* the electrode above the earth, and from it below, which system we may call C_2, their sum will be 0 above and $\frac{C}{2\pi r_1^2}$ below the earth's surface, and this is the real earth current.

Now, if we take the curl of the expression (2), we shall obtain the current C_1 (disregarding the wire current). We may do this by using the components of (2); or, more simply, thus:—The line integral of (2) round the circle of radius h perpendicular to the axis is

$$\frac{C}{h}(1 - \cos\theta_1) \times 2\pi h = \frac{C}{r_1^2} \cdot 2\pi r_1^2 (1 - \cos\theta_1).$$

This is $4\pi \times$ current through the circle (see p. 5). Now, $2\pi r_1^2(1 - \cos\theta_1)$ is the area of the portion of spherical surface with centre at N and radius r_1 bounded by the circle; consequently $\frac{C}{4\pi r_1^2}$ is the current-density.

Now, the curl of the magnetic force B of earth-current must be $4\pi \times C_2$. But C_2 and C_1 are identical within the earth, therefore B must be of the same form as (2), *i.e.*,

$$B = \frac{C}{h_1}(1 - \cos\phi) \quad . \quad . \quad . \quad . \quad (3),$$

where h_1 is the distance of the point considered from the axis of the earth-current (not of the wire), *i.e.*, the vertical through the electrode, and ϕ the angle between r_1 and this axis (positive direction) downwards. But, above the earth, C_2 and C_1 are oppositely directed; B must, therefore, be so changed that its curl becomes reversed. This may be done by making

$$B = \frac{C}{h_1}(1 + \cos\phi) \quad . \quad . \quad . \quad . \quad (4).$$

We may express (3) and (4) in one formula, thus:—

$$B = \frac{C}{h_1}(1 - \sqrt{\cos^2\phi}) \quad . \quad . \quad . \quad . \quad (5).$$

i.e., we take the numerical value of $\cos\phi$, whether it is $+$ or $-$.

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The actual magnetic force near the electrode is the vector-sum of (2) and (δ). One case may be noticed, where it simplifies. Let $\theta_1 = \phi$ and $h = h_1$ so that the wire enters the earth perpendicularly. Above the earth, we shall have

$$B = \frac{C}{h}(1 - \cos\theta_1) + \frac{C}{h}(1 + \cos\theta_1) = \frac{2C}{h},$$

perpendicular to r_1 and h. And below the surface,

$$B = \frac{C}{h}(1 - \cos\theta_1) + \frac{C}{h}(1 - \cos\theta_1) = \frac{2C}{h}(1 - \cos\theta_1).$$

We may now examine an interesting analogy which has a realisable existence, and may serve to clarify the above. Suppose that we have an infinite thin plane sheet of conducting material; choosing any point N in it for origin, let currents circulate in the sheet in circles about N, the strength being $\frac{C}{2\pi a^2}$ at distance a. If when we view the sheet we see the current circulate right-handedly, we see the negative side, and the + direction of the axis of the currents is from the negative to the positive side of the sheet. Now we have found the vector-potential of this current-system; it is expressed by equation (5), using the same notation as regards h_1 and ϕ. The magnetic force is the curl of (5), and is therefore radial, of strength $\frac{C}{r^2}$ on the − side and $-\frac{C}{r^2}$ on the − side. *I.e.*, the magnetic force of the current-sheet is that which would be produced by a magnetic pole of strength C placed at the origin, with this difference, that it acts as a + pole on the + side and as a − pole on the − side of the sheet, as shown in the diagram annexed. (We have here an

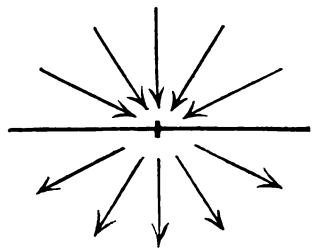


illustration of the continuity of the normal and discontinuity of the tangential component of magnetic force referred to in p. 33.)

How produce such a current system? Easily enough; permanently, if we had a sheet of infinite conductivity, transiently and imperfectly with a resisting sheet.

It is a cardinal truth in electrostatics that, when an uncharged insulated conductor is placed in an electric field, it becomes charged in such a manner that the force due to its charge exactly annuls that of the undisturbed field for all internal points, so that there is no electric force within the conductor.

Now, there is a corresponding theorem in electro-magnetics. If a closed sheet of infinite conductivity, having no current in it initially, be placed in a magnetic field, a system of currents will be set up in it of such a nature that the magnetic force due to it exactly annuls that of the undisturbed field within the space bounded by the sheet (or, in the case of an infinite sheet, on the further side from the source of magnetic force). Practically, with a resisting sheet, bringing it rapidly into the magnetic field, or, bringing the field to it, would set up the currents approximately, to be quickly killed by the resistance.

Let us then bring a magnetic pole of strength C suddenly to the origin on the + side. Its force is $\frac{C}{r^2}$ radial, on both sides. But there must be no force on the − side, by the above-mentioned theorem. So the magnetic force of the currents set up will be $-\frac{C}{r^2}$ radial on the − side, and on account of the reversal of the tangential component in passing through the sheet, it must be $+\frac{C}{r^2}$ radial on the + side. But since this field is exactly that produced by the distribution of current assumed before, it must be the current set up by the magnetic pole. The actual magnetic force of pole and current together is 0 on the − and $\frac{2C}{r_1^2}$ on the + side, *i.e.*, similar to the distribution of the current entering earth.

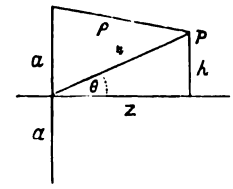
A magnetic shell which would produce the same field of force would have strength

$$\int_a^\infty \frac{C\,da}{2\pi a^2} = \frac{C}{2\pi a}.$$

This would be the magnetic moment per unit area.

[Test. Curl of intensity of magnetisation = vol. density of equivalent current. Taking the curl of $\frac{C}{2\pi r} \parallel z$, we find x-component $= -\frac{Cy}{2\pi r^3}$; y-component $= \frac{Cx}{2\pi r^3}$; z-component $= 0$. Resultant, $\frac{C}{2\pi r^2} \perp r$ in plane of sheet.]

As the mode of obtaining equation (5) may be considered obscure, it is desirable to check it by direct integration. It comes to the same thing if we find the vector-potential of the current sheet, current $= \frac{C}{2\pi a^2} \perp a$ at distance a from the origin. Let the sheet be in the plane of x y, and measure z positive from the origin on the + side. Let θ be the angle between r the radius-vector of a point P and z, and x, y, z the co-ordinates of P. First find the vector-potential at P of a circular unit-current of radius a. If h is parallel to the x-axis,



the y-components of the current contribute nothing to the vector-potential; the x-component of the element $a\,d\phi$ (measuring ϕ from the x-axis) is $a \sin\phi\, d\phi$; therefore the vector-potential of the circular unit current is

$$\int_0^{2\pi} \frac{1}{\rho} a \sin\phi\, d\phi \quad \ldots\ldots \quad (6).$$

Where ρ is the distance of P from the element $a\,d\phi$, and is given by

$$\rho^2 = r^2 + a^2 - 2ha\sin\phi.$$

The complete vector-potential of the current-sheet is therefore

$$B = \frac{C}{2\pi}\int_0^\infty \int_0^{2\pi} \frac{1}{a\rho} \sin\phi\, da\, d\phi \quad . \quad (7).$$

Let the limits for a be first a and ∞; a to be afterwards made 0. Then, by integration to a we find

$$B = -\frac{C}{2\pi}\int_0^{2\pi} \frac{1}{r} \sin\phi \log\left(\frac{1}{r} - \frac{h\sin\phi}{r^2}\right) d\phi$$

$$+ \frac{C}{2\pi}\int_0^{2\pi} \frac{1}{r} \sin\phi \log\left(\frac{1}{a} - \frac{h\sin\phi}{r^2} + \frac{\rho}{ar}\right) d\phi = B_1 + B_2 \text{ say.}$$

Now the definite integral

$$\frac{1}{2\pi}\int_0^{2\pi} \sin\phi \log(m + n\sin\phi)\, d\phi = \frac{m - (m^2 - n^2)^{\frac{1}{2}}}{n};$$

consequently, $$B_1 = C\frac{r - (r^2 - h^2)^{\frac{1}{2}}}{rh}.$$

Now, in the second integral B_2, a has to be ultimately 0. The quantity under the radical, *i.e.*, in the expression for ρ,

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therefore varies infinitely little from r^2, whilst ϕ goes from 0 to 2π. The quantity to be integrated then becomes of the same form as in B_1; but also, we shall have $m = \infty$, $\therefore B_2 = 0$. Thus

$$B = B_1 = C\frac{r - (r^2 - h^2)^{\frac{1}{2}}}{rh} = C\frac{1 - \sqrt{\cos^2\theta}}{h} \quad . \quad (8)$$

is the complete solution, showing that (5) is correct.

The integral (6) does not admit of finite expression, being elliptic (see Maxwell's "Electricity," Vol. II., Art. 701). Its expansion in spherical harmonics will furnish us with another proof of (8). Substitute for the circular unit current of radius a an equivalent plane magnetic shell of unit strength, so that there is magnetism of unit density on its + and of density -1 in its $-$ face. Let V be the potential of the + magnetism, then $+\frac{dV}{dy}$ and $-\frac{dV}{dx}$ will be the x and y components of the vector-potential. First find V for a point upon the axis, then

$$V = \int_0^a\int_0^{2\pi} \frac{a\,da\,d\phi}{\sqrt{a^2 + z^2}} = 2\pi\left\{(a^2 + z^2)^{\frac{1}{2}} - z\right\}$$

Expand this by the Binomial Theorem in powers of z, and call it V_1 when $z < a$ and V_2 when $z > a$. Then

$$V_1 = -2\pi z + 2\pi a\left(1 + \frac{1}{2}\frac{z^2}{a^2} - \frac{1}{2.4}\frac{z^4}{a^4} + \frac{1.3}{2.4.6}\frac{z^6}{a^6} - \ldots\right)$$

$$V_2 = 2\pi z\left(\frac{1}{2}\frac{a^2}{z^2} - \frac{1}{2.4}\frac{a^4}{z^4} + \frac{1.3}{2.4.6}\frac{a^6}{z^6} - \ldots\right)$$

Next let point be not on the axis; we may generalise the last by writing rQ_1 for z, r^2Q_2 for z^2, etc., in V_1, and $\frac{Q_n}{r^{n+1}}$ for $\frac{1}{z^{n+1}}$ in V_2, where the axis of Q's is along z. Thus,

$$V_1 = 2\pi a\left(1 - \frac{r}{a}Q_1 + \frac{1}{2}\frac{r^2}{a^2}Q_2 - \frac{1}{2.4}\frac{r^4}{a^4}Q_4 + \ldots\right)$$

$$V_2 = 2\pi a\left(\frac{1}{2}\frac{a}{r}Q_0 - \frac{1}{2.4}\frac{a^3}{r^3}Q_2 + \frac{1.3}{2.4.6}\frac{a^5}{r^5}Q_4 - \ldots\right)$$

Consequently the x-component of the vector-potential is

$$\frac{dV_1}{dy} = 2\pi\frac{y}{a}\left(-\frac{1}{2} + \frac{1}{2.4}\frac{r^2}{a^2}\cdot\frac{dQ_3}{d\mu} - \frac{1.3}{2.4.6}\frac{r^4}{a^4}\frac{dQ_5}{d\mu} + \ldots\right)$$

or

$$\frac{dV_2}{dy} = 2\pi a^2\frac{y}{r^3}\left(-\frac{1}{2} + \frac{1}{2.4}\frac{a^2}{r^2}\frac{dQ_3}{d\mu} - \frac{1.3}{2.4.6}\frac{a^4}{r^4}\frac{dQ_5}{d\mu} + \ldots\right)$$

according as r is $<$ or $>$ a. In getting the last expressions we have made use of the relations

$$\frac{d}{dy}(r^nQ_n) = -y\,r^{n-2}\frac{dQ_{n-1}}{d\mu},$$

$$\frac{d}{dy}\left(\frac{Q_n}{r^{n+1}}\right) = -\frac{y}{r^{n+3}}\frac{dQ_{n+1}}{d\mu},$$

where $\mu = \cos\theta$. The y-component is got by writing $-x$ for y, so that the actual magnitude of the vector-potential of the circular unit current is

$$\left.\begin{aligned}\frac{2\pi h}{a}\left(+\frac{1}{2} - \frac{1}{2.4}\frac{r^2}{a^2}\frac{dQ_3}{d\mu} + \frac{1.3}{2.4.6}\cdot\frac{r^4}{a^4}\frac{dQ_5}{d\mu} - \ldots\right) &= A_1 \text{ say}\\ \text{or}\\ 2\pi a^2\cdot\frac{h}{r^3}\left(+\frac{1}{2} - \frac{1}{2.4}\frac{a^2}{r^2}\frac{dQ_3}{d\mu} + \frac{1.3}{2.4.6}\frac{a^4}{r^4}\frac{dQ_5}{d\mu} - \ldots\right) &= A_2 \text{ say}\end{aligned}\right\} \quad (9)$$

Now, since the current strength in the sheet is $\frac{C}{2\pi a^2}$, the complete vector-potential is

$$B = C\int_r^\infty \frac{A_1\,da}{2\pi a^2} + C\int_0^r \frac{A_2\,da}{2\pi a^2}.$$

Substituting the above values of A_1 and A_2, and performing the integrations,

$$\begin{aligned}B &= \frac{Ch}{r^2}\left(+\frac{1}{2}\cdot\frac{1}{2} - \frac{1}{2.4}\cdot\frac{1}{4}Q'_3 + \frac{1.3}{2.4.6}\cdot\frac{1}{6}Q'_5 - \ldots\right)\\ &+ \frac{Ch}{r^2}\left(+\frac{1}{2} - \frac{1}{2.4}\cdot\frac{1}{3}Q'_3 + \frac{1.3}{2.4.6}\cdot\frac{1}{5}Q'_5 - \ldots\right)\\ &= \frac{Ch}{r^2}\left(\frac{3}{4} - \frac{7}{3.4}\cdot\frac{1}{2.4}Q'_3 + \frac{11}{5.6}\cdot\frac{1.3}{2.4.6}Q'_5 - \ldots\right) \quad (10)\end{aligned}$$

where Q'_n is written for $\frac{dQ_n}{d\mu}$.

We must now prove that (10) is the expansion of (8). Any function F of μ may be expanded in $\frac{dQ_n}{d\mu}$'s or Q''s; thus

$$F = F_1Q'_1 + F_2Q'_2 + \ldots$$

and the value of any co-efficient F_n is given by

$$F_n = \frac{2n+1}{2n(n+1)}\int_{-1}^{1} F(1-\mu^2)\,Q'_n\,d\mu.$$

Now in the present case B in (8) is

$$B = \frac{C}{h}(1 - \sqrt{\mu^2}) = \frac{C}{r}\cdot\frac{1 - \sqrt{\mu^2}}{\sin\theta},$$

and $1 - \sqrt{\mu^2}$ is such a function of μ,

$$\text{that } F\left(\frac{\pi}{2} + \alpha\right) = F\left(\frac{\pi}{2} - \alpha\right).$$

Also Q'_n is an even function of μ when n is odd, and an odd function when n is even. Therefore, since from $\theta = 0$ to $\theta = \frac{\pi}{2}$ we have

$$B = \frac{C}{r}\frac{1-\mu}{\sin\theta} = \frac{C}{r}\frac{\sin\theta}{1+\mu}$$

if we expand $\frac{1}{1+\mu}$ in odd Q''s between $\mu = 0$ and $\mu = 1$, the same expression resulting will give the proper value between $\mu = -1$ and $\mu = 0$. So we shall have

$$B = \frac{C\sin\theta}{r}\cdot\frac{1}{1+\mu} = \frac{C\sin\theta}{r}(F_1Q'_1 + F_3Q'_3 + \ldots)$$

where $$F_n = \frac{2n+1}{2n(n+1)}\int_0^1 (1-\mu)\,Q'_n\,d\mu,$$

and the limits being halved, the outer factor has been doubled, and only odd values of n are taken. Carrying this out, we shall obtain the expression for B in (10).

STUDENTS' COLUMN.—We regret that the pressure on our space compels us to leave over our Students' Column until next week.

TELEGRAPH POLES IN WASHINGTON.—The District Commissioners at Washington have decided not to allow any more telegraph poles to be erected in that city unless it can be proved that the public interests require them. It has been further decided that at the earliest possible moment the telegraph companies shall be required to lay their wires underground. For this reason an application made by the Baltimore and Ohio Telegraph Company to erect a line of telegraph poles has been refused.

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THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 32.)

If the resistance of the line, or external resistance, is increased from, say B A to B D (Fig. 30), and we wish to obtain the same current as before, then by drawing from D a line parallel to A E until it cuts B E, produced at F, and dropping F H perpendicular to axis, we get B H as the resistance of the battery in terms of B C, and F H as the electromotive force, in terms of C E.

If we have a given number of elements, it is desirable sometimes to know the best way of arranging them with any given external resistance, so as to obtain the maximum current in the circuit. The following well-known problem proves that the best way of grouping them is so that their resistance, if possible, should equal the resistance of the external conductor.

If a single pair of elements be cut into m elements, and these new elements preserving the same distance as before between each positive and negative element be placed in series, it is evident that the electromotive force will be increased m times, but as regards the resistance of the new arrangement, as the plates are m times smaller than the large pair, each pair must have m times the resistance of the large pair, and as there are now m times the number of pairs the total resistance of the battery now formed is $m \times m$ times, or m^2 times the resistance of the large pair.

Thus, if we cut the large pair in two and put them in series, we have twice the electromotive force, but four times

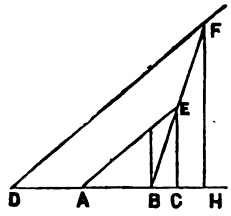

FIG. 30.

the resistance; or, if we cut the large plates in three, we shall have three times the E.F., and nine times the resistance; and, if in four, we shall get four times the E.F. of the large pair, but sixteen times the resistance, and so on.

If, now, we take as abscissæ of a curve these resistances, 1, 4, 9, 16, 25, &c., and as ordinates the electromotive forces, 1, 2, 3, 4, 5, &c., we see that the ordinates are as the square roots of the abscissæ, and the curve is, therefore, a parabol, a, as shown in Fig. 31. If we produce the axis A B, and take any length, A T, as an external resistance, and we now draw a line from T to any part of the curve, say to the point D over F, then the current in this arrangement of 16 elements will be proportional to the steepness of the line of potential T D, or, in fact, to $\frac{D F}{T F}$. But it is evident that the steepest line that can be drawn from T to the curve (that is, the line which, drawn from T, makes the greatest angle with the axis) will be the line which only touches it as a *tangent* as T K, which touches the curve as a tangent at E. The arrangement which gives the ordinate G E is, therefore, the arrangement which gives the maximum current with the external resistance T A in circuit. But it is proved in conic sections (Prop. IV., Cor. 2) that the subtangent A G is equal to A T. But A G is the resistance of the battery in the arrangement amongst them all, which gives the maximum current with A T as external resistance, and this is equal to the external resistance. The same can be proved, whatever length we take A T. Therefore, the best arrangement for cutting up any given surface of plates into is such that the resistance of the series formed shall equal the resistance of the external resistance. If we take any other series we shall find that there is always *another* arrangement which will give exactly the same current. Thus the dotted line drawn from T through D cuts the curve at H, showing that, with the external resistance T A, the series of four plates gives just the same current as the primitive single pair does. Thus, if A T equals four times the resistance of the single pair, then we have for current in the circuit, in figures, $\frac{1}{5}$, and for the current with the four plates $\frac{4}{4+16} = \frac{4}{20} = \frac{1}{5}$, *i.e.*, exactly the same current as with the single pair. In the same way with any external resistance, if we draw a line *cutting* the curve at all it will cut in two places, and we get two points of cutting, each of which will give, by the arrangement of plates it represents, exactly the same current.

The following various groupings of 104 elements will illustrate to the student this problem of the arrangement for maximum current in actual figures. Suppose the 104 elements to be each 1 volt E.M.F., and 1 ohm resistance, and let the external resistance be 4 ohms. Then, if we group all the elements in series, we get

$$\frac{104 \cdot}{104 + 4} = \frac{104 \text{ volts}}{108 \text{ ohms}} = \text{current of } 0{\cdot}96 \text{ ampere.}$$

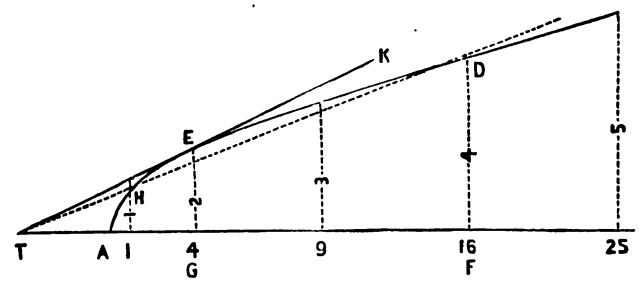

FIG. 31.

If, now, we arrange the battery in two rows of 52 elements each, we get

$$\frac{52 \cdot}{26 + 4} = \frac{52 \text{ volts}}{30 \text{ ohms}} = \text{current of } 1{\cdot}73 \text{ ampere.}$$

Now, making four rows of 26 elements, we get

$$\frac{26 \cdot}{6 \cdot 5 + 4} = \frac{26 \cdot \text{ volts}}{10 \cdot 5 \text{ ohms}} = \text{currrent of } 2{\cdot}47 \text{ ampere.}$$

It will be seen that this arrangement is the one which most nearly gives a resistance of the battery equal to the external resistance, for if we sub-divide again we get 1·625 as resistance of battery, and for current

$$\frac{13}{1{\cdot}625 + 4} = \frac{13 \text{ volts}}{5{\cdot}625 \text{ ohms}} = \text{current } 2{\cdot}31 \text{ amperes.}$$

This arrangement does not, it will be seen, give a current as great as the previous one, which is consequently the grouping that will give the maximum current, and is the one in which the resistance of the battery most nearly equals the external resistance.

NEWS FROM PANAMA.—Intelligence from Panama dated November 16 says:—"The cable steamer 'Duchess of Marlborough' is now in Colon, and is about to proceed to repair the cable thence to Jamaica, which is broken at a point about thirty miles from the point. [This cable has been repaired within the last few days.] The Central and South American Cable Company has determined to cut the T piece out of its line—the shank of which now gives us our connection with the system—and to bring the ends of the northern and southern cables into this city. This will much diminish the power required in transmitting."

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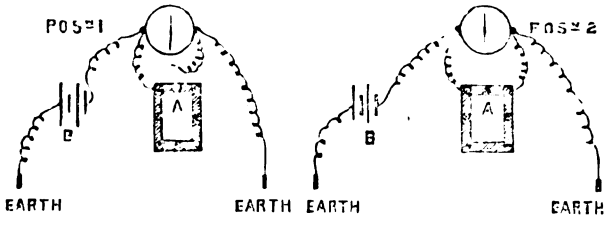
A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

X.

Before commencing to take the constant we must see whether a shunt is necessary, and, if so, arrange it as explained in a former number. The resistance through which we are working is one megohm, and the battery consists of, say, 200 cells. It is possible, however, that the learner may find that there is no megohm at hand; and though this resistance is rarely wanting in a testing room, yet sometimes it is necessary to determine the constant with a resistance no higher than 10,000. We shall presently show how to proceed under such circumstances. For our test we will merely say at this point that with a megohm a shunt will be necessary, and the resistance which it ought to have will probably be on record, as it is chosen with reference to these conditions of standard resistance and battery, also to the resistance of the particular galvanometer employed. But in relation to the cable which is to be tested, a few words are needed to guide the student in the matter of shunt selection.

For a short length of cable, say a few knots, we should, if any were needed, require a shunt of much higher resistance than could be made with coils as generally limited. In fact, the shunt circuit must be broken, technically speaking, and our shunt would have what is called infinite resistance—the shunt would be said to be infinite. A little difficulty may at this point become evident to the learner, arising from the fact that when "infinity" is used for a shunt the test is said to be taken with "no shunt," and he will note that if all the plugs in the shunt-box were inserted there would be no shunt

Fig. 20.



Infinity Shunt (No Shunt.) No Shunt, but Galvr. short circuited.

in circuit, but the results in the two cases would be very different. In the first case practically all the current goes through the galvanometer, in the latter the instrument is short-circuited, and no current passes through it. In Fig. 20, at position 1, we have infinity shunt; in position 2, all plugs are inserted in the shunt-box. In a sense, "infinity" is the highest possible shunt, because it shunts off the least possible amount from the galvanometer. It is best not to use the expression "no shunt" for both cases, but to say "infinity" and "no" shunt respectively.

There is another point not yet mentioned on which the results given by the galvanometer depend, and it applies to all tests. The object being to have a large deflection, yet, of course, within the limits of the scale, all the governing conditions must be taken into account. We have mentioned the battery, the resistance of the galvanometer coils, and the shunt, but one very important feature is the sensitiveness of the instrument. By this we mean the amount of freedom allowed to the little mirror when tending to swing under the influence of the current on the tiny magnet attached to it. Every galvanometer has a controlling magnet, the form almost universally employed being that of a curved bar which slides up and down on a rod mounted in the centre of the cover. Its length is about that of the diameter of the latter. The north pole of this magnet must be on one particular side determined by experiment or a knowledge of the position of the poles of the little mirror magnets. If the controlling magnet is low down on the rod it limits the swing of the mirror considerably, and the higher it is pushed up the rod, the more freely will the mirror deflect. Any alteration, therefore, in its position on the rod must be taken into account in using the instrument, because if the battery and shunt with the circuit resistance were the same at two different times, and the controlling* magnet were shifted, a different deflection would be the result.

To return to the test. Having arranged our shunt, let us depress the left-hand key and clamp it down. The short circuit plug remains inserted for a few seconds after charging, and the operator must be exceedingly careful not to charge unless assured that this plug is in its place. If it were not there the charge would rush through the galvanometer coils, and probably demagnetise the little mirror magnets. Immense trouble has been occasioned by a mishap of this kind. When the little magnets are demagnetised (deprived of their magnetism) they no longer yield properly to the influence of the current through the coils, and deflections given by the mirror are anything or nothing. The controlling magnet also influences the little ones irregularly; the whole thing is upset, and much trouble may occur in repairing the arrangement. The little magnets must be magnetised afresh, and the mirror probably be resuspended, that is, have a fresh fibre attached. We mention this to impress the caution on the learner's attention.

After the 15 seconds above mentioned, the short circuit plug will be removed gently and by degrees, with a slight jarring motion to control the movement of the spot. This will now be seen to move down the scale, and, swinging a little while, more or less according to the care with which the plug has been taken out, will finally come to rest, and its centre marked by a fine line (reflected on to the mirror by means of a wire in front of the light) will mark the division which is the limit of the deflection—we may suppose it marks the 300th. The value for constant is, therefore, 300, and if the multiplying power of the shunt were 150, we should have, as before shown, 45,000 millions for the constant. We have now to take off the battery. But here, again, the caution at first given must be observed. Before releasing the battery key, the short circuit plug must be replaced for the same reason which compelled us to avoid taking it out, except that in this case of taking the battery off it is the *discharge* of the current through the galvanometer that is to be avoided. The million resistance is now to be disconnected, and the cable joined up in its place. The proper shunt must be arranged to cause the deflection to be as nearly as possible the same as that of the constant after the cable shall have been charged one minute. The reason is that the influence of the current in the galvanometer coils shall be as nearly as possible equal in both cases, and therefore a fairer comparison obtained. When a number of cables of the same type are to be tested, it is easy after properly testing the first to arrange the shunt, since a smaller shunt is required as the length increases. The same plan for finding what shunt ought to be used when total uncertainty prevails on the point in this test will not be followed as suggested for a capacity test; for as 200 cells are being used the cable can only be charged once, namely, for the purpose of the test, and beyond this the capacity would not be interfered with as the insulation resistance would, because the conditions are not the same. A little consideration of the explanations already given in relation to these two operations will make the matter clear. For lengths of cable below twenty knots, generally speaking "infinity" shunt will be used, but all depends on the type and quality of the cable and the resistance of the galvanometer employed. When with this shunt we cannot get a readable deflection, it is customary to use 30,000 or 40,000 ohms resistance as the next lower.

Before charging the cable for the test the operator should look over the connections and see that all is right. If the constant has come out satisfactorily there is nothing to change, but all the connections should be tight, and no leads touching each other or anything likely to cause leakage (of the current). Then the key is to be depressed and clamped down. After 15 seconds the short circuit plug is lifted as before and laid aside. The spot will probably pass off at the

* This magnet serves another purpose, but it need not be discussed at this point; it involves considerations beyond the limits of elementary teaching.

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end of the scale at first, and shortly be seen returning more and more slowly. It must be watched, and, if all is right, will move steadily, always in the same direction, back towards zero. At the end of one minute from the time of charging a reading will be taken, and generally also at two minutes and five minutes; in each case the number of the division marked by the centre line of the spot is recorded. After the fifth minute the short circuit plug will be returned to its place, and then, but not before, the battery key may be released. If other sections of cable are to be tested, they will follow in their turn. When all are finished it will be proper to take the constant again to see if there be any change in the galvanometer coils. It may, perhaps, be found that the deflection is larger or smaller than it was at first. If so, the mean of the two readings should be accepted.

Supposing we were to keep the current on for a considerable time, instead of freeing it as stated, and also keep the plug out, the spot would continue moving back for a period varying with the length of the cable under test. Perhaps after thirty minutes it would be nearly stationary; it is not usual to observe the movement for more than half an hour in any case where the section is perfect, but we mention the time merely to show what passes, and for the purpose of considering the conditions governing the operation.

There are certain points to be noted in connection with this test, and, first, the spot ought to start exactly from zero when the short circuit plug is lifted, and should also return to it when this plug is replaced. When a five-minutes test is taken, it (the plug) should be once or twice inserted to bring the spot back to zero, and if it be found to have shifted, and is not now exactly on the line, the difference must be taken into account. If it is on the other side of zero, say, one division, then one will have to be added to the number of divisions given by the last reading; if it falls one division short of zero, then one less will be counted. At the same time the scale, which is movable, can be pushed either way to bring the line of zero under the centre line of the spot. As all these observations ought to be very accurate it is essential that the galvanometer used should keep its zero well.

Another point to be noticed is that the deflection should be on the same side of zero for both constant and cable test. We are supposing the zero to be in the centre of the scale, though, practically, it might be arranged to make one end the zero point, and to let the spot traverse the whole length; but where this is not done, the deflections can, of course, be made right or left, according to the position of the plugs in the galvanometer commutator. Theoretically the mirror swings equally either way for equal currents and circuits, but in practice it sometimes happens that, under similar conditions, a deflection to the right may be a division or two more or less than on the left. This may be owing to imperfect levelling of the galvanometer stand or to torsion in the fibre by which the mirror is suspended. Therefore it is safer to arrange the four-way commutator as hinted above.

We have said that other forms of commutator are used for regulating the direction of the deflection besides the four-way piece here suggested, and when this is the case, an extra key must be provided for short circuiting the galvanometer. The plug commutator is specially convenient, because it combines the two requirements. In Fig. 21 a double-current key is shown for commutator, and a short-circuit key for admitting or excluding the current from the galvanometer. The short circuit key acts thus—the point G is connected conductively to F by the key piece, which presses against the bar Q, and thus makes a metallic path of (practically) no resistance; if the key be depressed the path is severed, and a current would pass through the galvanometer as the only way open to it. In the figure the battery key is omitted, though in practice it would be employed, as well as the battery commutator formerly illustrated. The comparison of the different arrangements is seen by observing Fig. 22 at the same time with Fig. 21. In the former figure position 1 compares with the effect of depressing the left hand key, L, in the latter, and position 2 compares with that depressing R, the right hand key in that figure. In the first case, by putting down L the current passes to the lower bar, J, and so to G, when, if the short circuit key is depressed, it goes round the galvanometer coils in that direction, entering on the *right* hand (facing us). This is just as it would do in position 1, where it passes to G, and, if the plug is out, goes through the galvanometer on the same side following the arrows. Reversing this direction, and depressing R, the current goes by L to the upper bar, H, L being up and pressing against it, and passes to F, entering the galvanometer on the *left* hand (facing us), that is, if the short circuit key is down. Comparing this with position 2, the current goes to G, and the plug Q, whose

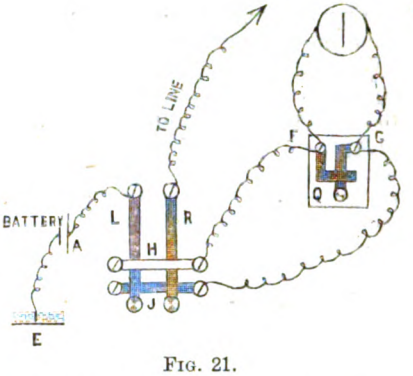

Fig. 21.

place is changed, being removed, passes by F round the galvanometer by the left side (facing us). The only difference is that, in the plug commutator, the current enters at G in both positions (Fig. 22), and, in position 2, afterwards goes by F. In the key commutator, Fig. 21, it enters, in the first case, at G, and, in the second, at F, going *direct;* it comes to the same thing, however. The letter Q in Fig. 21 is repeated in both positions in Fig. 22, as marking in each case the means of opening or closing the circuit—in the former by the small key, in the latter by the plug. The letter G, in

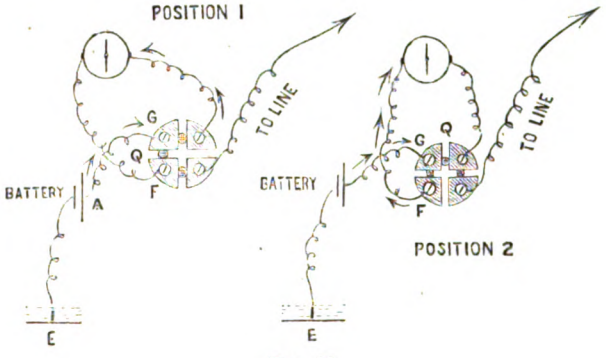

Fig. 22.

positions 1 and 2, is not placed against the galvanometer lead as in Fig. 21; but this is immaterial, as the four-way piece is both commutator and short circuiter. The short circuit is between the terminals of the galvanometer all the same, since the other plug connects G to the next quadrant.

In the next number the subject of the Insulation Resistance Test will be continued, as several points remain to be considered.

The Volta Prize of 1887.—An official notice states that the prize of 50,000 francs, instituted by decree dated the 11th June, 1882 (known as the Volta prize), and intended to be conferred on the author of the discovery which shall render electricity an economical agency either as a source of heat, light, chemical action, mechanical power, means for transmitting despatches or the treatment of illnesses, will be conferred in December, 1887. All nationalities are allowed to compete, and the competition will remain open until the 30th June, 1887. A commission will be appointed by the Minister for Public Instruction, Paris, to report on the discoveries, &c., which may be entered for the prize. Professor Graham Bell was the last recipient of this prize for his researches in telephony.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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FIRE ALARUMS.

The season of great fires appears to have set in with unusual severity. Not long ago the alarm created by armed burglars furnished a text for the introduction of alarums to warn the peaceful householder of his danger. The present epidemic of fires seems to call for similar exhortation with respect to peril of a different kind. Bad as he is, the midnight thief is seldom an incendiary, and at his worst does not rob us of as much property as an outbreak of fire generally destroys, nor endanger so much life and limb as it not infrefrequently does. In the case of fire, it is true, there is the insurance policy to fall back upon, whereas against theft there is no such consolation. But from the public point of view, that is to say from the point of view of our common interests, a fire is a calamity, and ought to be regarded in that light by the insured as well as the insurers. Perhaps this fact is a trifle too much overlooked, the Insurance Companies, like the Poor-law guardians, having demoralised us somewhat in respect to personal responsibilities. It needs, or ought to need, no moralist or political economist to teach us that what is destroyed by fire is a dead loss to us all, and is irreparable, notwithstanding the ready response of the fire office. Though scientists may tell us that nothing is really destructible, it affords us no sort of recompense to have our property returned to us in smoke, especially as we have enough of that commodity already. Next to a failure in the natural fruits of the earth, a fire is, in its degree, to be classed as a national disaster. There is no exception to this rule, unless it be the cleansing by fire of fever dens, whose owners refuse to renovate them in any other way, and which may be advantageously lost for the general gain in health.

Elementary as are these notions about the literal destructiveness of fire, they appear to be, as we have already hinted, partially forgotten, otherwise the precautions against such visitations would be far more general and complete than they really are. At this time of year, if we mistake not, the frequency of fires is particularly noticeable. Some people attribute them to the impending Christmas bills, others again to the slack season, whilst others more charitably explain them by the obscurity of the days and the length of the nights, involving the constant, and therefore careless, use of gas light. Be this as it may the fire brigade has little or no rest when the fogs and the frosts set in; and every morning's newspaper brings its quota of fires big and little to swell the winter's total. It is true we hear nothing of the fires that have been instantly put out, or of precautions proving efficacious just when they are wanted; but making allowance for these it does strike one as portentous that so many fires, and fires, too, of such huge dimensions, should do their cruel worst while man stands helplessly by.

For this is really what does happen. In the very establishments where precautions should be of the most painstaking, where the risk is the greatest, and the consequences of neglect the most deplorable, there we never hear of any special safeguards whatever. As to fire alarums, if they exist, they appear to be dumb, and when once a flame is kindled in such edifices all the water that the best engines in the world can shower upon it seems powerless to stay its progress. Electric fire alarums of various kinds have been in the market for a considerable period. If the present quite phenomenal series of conflagrations induces either the owners of property or the insurance societies to promote the adoption of such appliances some good may come of it. We are glad to notice that a company has been formed for the purpose of pushing the sale of alarums of this kind. We know little of the promoters or of the particular device advocated by them; but we heartily wish them success, and that they may profit by what we may call the present excited state of the fire market. The ways of giving timely warning of a fire by means of electricity are so numerous that we need not specify them here. Theoretically, there is no agency which, appropriately used, so readily lends itself to indicating changes of temperature as electricity may be made to do. Many ingenious devices have already proved their efficiency, but there is still plenty of room for inventive skill to find its reward in this particular field of practical usefulness, and now that a company has been started to promote the introduction of such contrivances, a ready sale may be counted upon for any invention that promises real improvement.

To add to the urgency for some additional safeguards or instantaneous warnings nowadays more than ever, it is currently stated that the present fashion of building is peculiarly

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weak against the assault of fire. We do not allude to the lath-and-stucco "desirable residence" in which the City clerk is compelled to die, or to the mud-built cottage provided by jerry builders for the suburbanised British workman. Saturated with moisture unspeakable, these habitations refuse to burn. But not so the stone-built, iron-girdered "blocks," which of late years it has been the prevailing custom to erect for what are esteemed our City improvements. Bricks which have already stood the brunt of a fierce furnace will, we are assured, stand it once again without injury, and if well put together with honest mortar will survive where stone will crumble to pieces. Add to this the fact that iron, now so universally used in construction, swells inordinately and literally bursts the edifice outwards when subjected to a high temperature, and we have all the conditions requisite for enlarging the area of conflagration and augmenting its material injury. Under these circumstances the necessity for introducing in buildings so constructed a trustworthy and efficient alarum is perfectly evident; and we hope the time is not far distant when this will be one of the conditions upon which future fire policies will alone be granted.

CORRESPONDENCE.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to the article by Professor Blyth, from the *Proceedings* of the Royal Society, Edinburgh, contained in your issue of 25th November, which I read with much interest, I cannot accept the result of experiments therein by any means as a proof that resistance of the carbon contact in the transmitter is *not* subject to changes in its normal resistance under pressure, or that the experiment with 20 Grove cells illustrates the action in a transmitter.

Experiments which I have made in this direction lead me to quite a different conclusion—viz., that the microphonic action which takes place in a transmitter *is due* to the variable resistance of carbon, under varying pressures, with a closed contact, and not, as the inference to be drawn from the paper in question would set forth, by a "make and break," or what I will term an intermittent contact.

I trust that the learned professor, and the distinguished physicists referred to in the above paper, will excuse me indulging in a little "rank heresy."

It would seem throughout the wordy warfare which took place in discussing the validity of patents held by the United Telephone Company, that Edison's beautiful instrument, the tasimeter, was completely lost sight of, in which a carbon button varies its resistance under the effect of *pressure* due to the expansion of a solid undergoing a change of temperature. As the tasimeter button in some cases is composed of compressed lampblack, it will be advisable in this case to take an ordinary Blake transmitter, in which a hard carbon button bears on a platinum stud, as a means of demonstrating my experiment.

In regard to the assertion that a loose or intermittent contact exists, I would refer the reader to Diagram No. 1, which shows the working portions of a Blake transmitter in skeleton.

D is the iron diaphragm which is subject to the most microscopic motion only.

P platinum stud suspended by a very thin ribbon of German silver, R, and bearing on the diaphragm D.

C is a button of hard carbon held in a brass cell, B, which is screwed to a comparatively strong steel spring, S, and is forced in the direction of the arrow by an adjustable lever (not shown) against the stud P, and through it the primary circuit is completed, the route of the current being down S, through B and C, to P, thence up R.

The lever in connection with the spring S is adjusted so as to force the carbon button carried by the spring S against the platinum stud P, with a *continuous pressure* in the direction shown 40 to 50 grains. It might be argued that the weight of the carbon block and cell would be sufficient to neutralise this force, but, seeing that the arc described by the carbon button responding to such vibration is excessively small, the *versed sine* or actual lift must be infinitesimal and may therefore be ignored, leaving the continuous thrust of the spring (which is surely sufficient) to overcome the *vis inertiæ* of the mass suspended, and moving in a practically horizontal plane.

Is it, therefore, probable that such vibrations could be imparted by the voice to the iron plate that would be capable of interrupting the continuity of the contact between carbon and platinum, when the iron plate is "damped" by a strong steel spring (not shown), and when the carbon is kept "up to its work" by a force exerted by the spring S, of say 45 *grains?*

The question admits of one answer only, but this I leave for every one to form an opinion thereon from the facts I have given.

This point, however, is not of great importance, for if it can be shown that carbon varies its resistance under minute changes of pressure it proves that microphonic action will take place on a closed contact, and that it is not necessary that an intermittent contact does and should exist, as per the last paragraph of the article herein referred to. It therefore will follow that Professor Blyth is wrong in making the deduction that the microphone is practically a Reis contact.

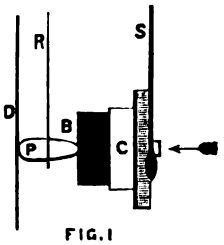

FIG. 1

Regarding "the filling of the gaps with material which is sensitive to the harmonic variations of the atmospheric density," and in illustration of which a diagram of apparatus is given which was used in conjunction *with* 20 *Grove cells* (the italics are mine), all I can make of it is that the professor has constructed a very respectable arc light, and practically demonstrated a question which appeared in a scientific paper lately, "Was the electric arc capable of microphonic actions?" made by some one who had found this action to exist in ordinary flames, but evidently had not the means at his disposal to make the experiments on the arc. Professor Blyth says there was no effect produced when the carbons were in contact, but had to draw them apart, and not until the *electric arc was visible* did the microphonic action take place, which *again ceased* as the carbons were consumed, and the distance from each other had become too great for the current to surmount. It is obvious, therefore, that the action was not produced by the vibration of the carbons relative to each other, but to vibrations of the arc, the carbons being completely divorced and maintained at a *finite distance apart*, a condition which is impossible in a telephonic transmitter.

Further, there is no transmitter in the market which requires 20 Grove cells, and, for the sake of the battery man, I trust there never will be. It is presumable that if the effect could be produced by *one cell* the professor would not have used 20.

The Blake transmitter is one of the best, if not the best and most economic, in the market at the present day, requiring only one No. 2 Leclanché, and from this fact, and the construction of the contact as before described, it is apparent no such effect can exist, and the probability of it ever being made use of for telephonic purposes is very remote.

The method which I adopt to demonstrate the effect of vary-

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ing resistance is as follows:—I connect up the primary circuit of a Blake transmitter, with the Wheatstone bridge and a tolerably sensitive galvanometer balancing the resistance, as shown in Diagram No. 2.

1st. I find on blowing into the transmitter opening the force exerted by the breath was sufficient to send the pointer of the galvanometer with vigour to the extreme end of the scale, showing that the normal resistance of the carbon has been altered in a very considerable degree; and, 2nd, on separating the carbon-platinum contact, the needle vibrates to the opposite side of the scale, thus proving that the effect in the first case was to *minimise* the resistance. 3rd. Thinking this effect might be caused by an increase of temperature, I used a pair of bellows *with the same result*. 4th. To avoid the vibratory motion which might be set up by the rush of wind, I took a bristle out of an ordinary hearth brush and pressed it against the diaphragm, and found the *greater the pressure put on the bristle* the *greater* the deflection.

Therefore, the resistance varied inversely as the pressure varied, and on releasing the pressure of the bristle *steadily* the needle returned practically without variation to zero, and I have come to the conclusion that the difficulty which is experienced by the needle in regaining the initial position when experimenting with carbon is due to mechanical trituration, and if proper precaution had been taken to eliminate vibration in the above case, when the experiment was performed in a rough and ready manner on a very shaky table, the needle would have regained its original position without appreciable deviation. When I have more time at my disposal I intend going very carefully into this point, and, with your kind permission, will send the result of experiments for publication.

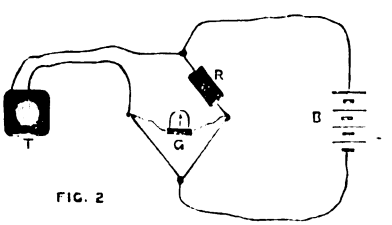

FIG. 2

Could any one conceive the resultant force acting on the carbon exerted by the bristle through the medium of the iron plate? Is it to be wondered at, considering the method herein described, that experimentalists fail to demonstrate the variable resistance of carbon by such means as "vices," "levers," *et hoc genus omne*, even unto the "bending" and "crushing," with which I can only compare an attempt to measure the network of a spider's web with a land chain.

The deductions which I make from the foregoing experiments are, 1st, that the normal resistance of the carbon is diminished on pressure being applied within certain limits, which regains its normal resistance on the pressure being removed.

2nd. The current will be proportionally increased as the resistance is diminished.

3rd. Induced currents will be set up in the secondary coil by the variations of current flowing in primary and in proportion to their intensity.

4th. That the variation of the primary current will be proportional to the vibrations of the diaphragm, which will in turn respond to the magnitude and intensity of the sound waves which impinge on its surface.

Therefore microphonic action takes place independent of an intermittent contact with or without matter filling the gaps.

The rise and fall of the primary current is in a wave like form, and which gradual rise and fall the induced currents will follow. If the intermittent contact theory existed we should have an abrupt or short-stopped effect, and the induced currents would be developed in like manner, giving rise to a harsh crackle, in place of the mellow cadence of a well made and adjusted transmitter. The effect of a slack transmitter producing intermittent contacts is peculiarly characteristic, and once heard not readily forgotten.—Yours, &c.,

R. D. SMILLIE, Electrician.

National Telephone Company (Limited),
Glasgow, Dec. 6, 1882.

CHARGING SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We have to thank Mr. Bosanquet for pointing out an omission in our paper of the week before last.

Although for convenience of discharging we join the first cells on to the switch five at a time, we find it too great a drop, as he points out, to change from five ohms to five cells, and we now always "flash" the handle round to the second or third stop.

The proper number (x) of cells to replace any given resistance, R, with a current, C, being obtained from the formula $x = \frac{C R}{C\rho + e}$, where ρ and e are respectively the internal resistance and E.M.F. of one cell.

E = E.M.F. at terminals of shunt.
C = current.
R = resistance of shunt.
ρ = internal resistance of one cell.
e = E.M.F. of one cell.

$$E = C R.$$
$$E = C x\rho + x e.$$
$$C x\rho + x e = C R.$$
$$x = \frac{C R}{C\rho + e}.$$

We have generally found that our secondary cells have, immediately after charging, an E.M.F. higher than their normal one; it is, therefore, always advisable, before taking the E.M.F. of an experimental cell, to circuit it for a short period of time through a small resistance.—Yours, &c.,

C. W. S. CRAWLEY,
E. C. RIMINGTON.

School of Electrical Engineering,
12, Prince's-street, Hanover-square.

"IOLANTHE" AT THE SAVOY THEATRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reading through the description you give of the portable electric lights now employed at the Savoy Theatre, we notice that you do not mention that the specially small incandescence lamps were constructed for the purpose by Mr. Stearn, of the Swan Company, and that his having succeeded in still further modifying their details enables us to reduce the weight of the new batteries to about 3lbs.

At the same time, as we are desirous that credit should be given to whom it is due, we beg to point out that it is our assistant, Mr. Koeppler, who has had charge of the electric light installation at the Savoy Theatre from the beginning, and that Mr. W. S. Rogers, to whom you refer, was only engaged in perfecting the working details of the small portable lights in question.—Yours, &c.,

SIEMENS BROTHERS and Co. (Limited).

12, Queen Anne's-gate, Westminster, S.W.,
December 12, 1882.

PHOSPHOR BRONZE WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 2nd inst., which has just reached me, I notice a reference to my phosphor-bronze wire, in a table of results furnished by Mr. L. Weiler. I am thus forced, much against my desire, to beg you to insert this protestation. Phosphor-bronze is not, as you state, a new alloy, since the Phosphor-Bronze Company in London was

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founded upon the purchase of my patent in 1870. Nor is Mr. L. Weiler the inventor of its application for telegraphic purposes, his knowledge on the subject having been acquired from me and his visits to my works whilst he was acting as manager for his brother, who was my agent for the sale of this wire in France.

As long as Mr. Weiler was content to prove the material he sells I have had no wish to rush into print and gain a cheap advertisement; but I am forced to protest against his introducing my manufacture into his tables of comparison for the purpose of showing his superiority, the figures he gives being entirely fanciful and erroneous and opposed to the truth.—Yours, &c.,

G. Montefiore Levi, C.E.

35, Rue de la Science, Brussels, Dec. 7, 1882.

OHM'S LAW.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I am much obliged by Mr. Harvey's letter, but it does not explain the difficulty which presents itself to my mind. At first sight it appears extremely likely that a conductor having double the capacity would convey double the quantity; but I have not at present tested that fact as I intend to do. I do not see when a river flows much faster in a narrow and shallow part than it does in a broad and deep part—but the same quantity of water passes in the same time—why electricity obeys a different law, and I cannot help thinking that the heating of a finer wire more than a larger one is due to the greater rapidity with which electricity passes. If the effect of resistance is to retard the consumption of the zinc in a battery, or rather I should say the conversion of it, then it appears to me very inaccurate to describe that *portion* of the electromotive force which is used as *the* electromotive force. Nor can I understand when a resistance of 10 ohms would suffer sufficient electricity to pass to raise, say, 100lbs., and a resistance of 20 would only permit sufficient to raise 50, and a resistance of 40 would only permit sufficient to raise 25lbs. (which would be the case if current is to be multiplied by resistance), why 10 ohms, when the increase is from 10 to 20, should cause a reduction of 50, when a further increase of 20 would only cause a reduction of 25. Nor can I understand why the resistance retards the chemical action, which it seems to me it must do unless a force can be created if the quantity passing is to be multiplied by the resistance.—Yours &c., J. A. S.

ELECTRICAL ACCUMULATORS OR SECONDARY BATTERIES.*

BY PROFESSOR OLIVER LODGE.

No. IX.

The coatings of both plates being now fully formed, the one all peroxide, the other all metallic lead, the gas which is liberated against their surfaces is no longer absorbed, but begins to rise in considerable quantities, at the same time that by making the plates into a gas-battery the free gas adds distinctly to the electromotive force of the cell. The fulness of the cell can therefore be told in these two ways—a greater escape of gas and a higher opposition electromotive force than usual.

The proper or "ohmic" resistance of the cell is now a minimum, however, for three reasons—because the conducting surfaces, the front surface of the peroxide and the front of the reduced lead, are as near as they can possibly be; because the acid in the solution is as concentrated as it can become, that which had been absorbed by the lead having been restored; and because the cell will have been warmed by the charging current. The cell is, therefore, in all respects at its very best, and it can give a tremendously powerful current for a few seconds if called upon.

But suppose it is not called upon for a current, but simply allowed to stand idle for a time, what will happen to it? First, of course, it will cool, and thereby slightly increase its resistance; but, more important than this, the gas which is clinging mechanically to the surface of the plates will collect in bubbles and gradually rise, thus lowering the electromotive force from its abnormal value. The gas which first escapes, however, will be the oxygen; a large quantity of hydrogen will remain half alloyed with the lead plate, more especially, perhaps, if it is amalgamated, and accordingly the electromotive force, though it loses its abnormal value, retains a perfectly satisfactory one.

No further change of importance need be expected to be noticed after the lapse of several minutes or even an hour, but if the cell is set aside for a day or two a more serious change sets in. The front surface of the lead loses some of its hydrogen, and is liable to be corroded slowly by the acid, a slight scum of insulating sulphate being produced; and these changes, though they go on with extreme slowness in a good cell with its terminals properly insulated, yet are exceedingly weakening when they do occur, because they lower the electromotive force and increase the internal resistance at the same time. A plate well saturated with hydrogen, however, will resist the formation of any such scum for a considerable time, and I see no reason why it should form in any quantity for a week or so, provided there is no leakage between its terminals. I apprehend, however, that a temporary short-circuiting of the full cell before setting aside, whether for the purpose of testing or for other purposes, would have a detrimental effect by diminishing the store of hydrogen, and that a cell so treated would not bear standing idle quite so well as a perfectly full one.

The main part of the change which occurs during standing seems to take place at the + plate. Here the peroxide is in contact with and supported by a plate of metallic lead, and the peroxide is sufficiently porous to allow some of the acid liquid to penetrate to the junction of the two substances; hence there is here a complete battery, and, accordingly, a certain amount of local action sets in, some of the lead becoming oxidised and sulphated, while some of the peroxide gets partially reduced. If this action goes on to any general extent it is most disastrous, for the effect is to establish a non-conducting film or layer of sulphate and lower oxides between the lead plate and the rest of its peroxide coating; and it may sometimes happen that the coating is thus completely detached from the plate so as to become quite useless. But, suppose it only gets detached in patches, the internal resistance will thus be increased, and the storage capacity will be diminished almost by the total amount so detached, but the electromotive force would not be likely to be diminished until the effect of the local action had extended itself through the whole *thickness* of the peroxide. After a long time it, probably, would so extend itself, and thus the peroxide would get reduced by mere standing without any current having been demanded from the cell.

Messrs. Gladstone and Tribe have called attention to this local action, and pointed out one reason why it goes on more slowly than might at first sight have been expected, viz., that the crust of sulphate formed on the lead protects it by its insulating power, and only permits deeper portions to be acted on by reason of its porosity. Another reason why the action is not at all rapid is that the surrounding mass only permits a very insignificant amount of circulation in the liquid, so that it soon gets exhausted of its acid, and is only slowly replenished by diffusion. Still the local action does go on more or less rapidly, and it is, so far as I know, the main cause of the loss of power of the cell while standing. Moreover the differences noticed among different cells seem to depend very greatly on the facilities which some seem to offer to this action, and to the consequent greater or less detachment of the peroxide coating. Why the coatings detach themselves in some cases more readily than in others is by no means clear; but it may happen that a too rapid evolution of gas, caused by a too powerful charging current, might mechanically effect a separation between the plate and its coatings. It must be remembered, however, that the coatings may easily become electrically detached by an insulating

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film—especially in patches—and yet their mechanical adherence may remain almost unimpaired.

The naturally occurring cure for these evils would be either to support the peroxide on carbon, or other such non-attackable substance, or else to use no support at all, but to make the plate wholly of peroxide. But though the use of carbon would do away with local action, scarcely any form of carbon can resist the action of nascent oxygen, and accordingly its surface crumbles during charging, and the powder makes a worse barrier than ever to good conductive connection between the plate and its coatings; in fact, the coatings are liable in time simply to drop off. The use of peroxide alone looks hopeful, but when the cell is discharged and the peroxide reduced the plate will no longer be a conductor, and it does not appear probable that such a cell could ever be charged up again. Moreover, the difficulties of making good and permanent contact with such non-metallic substances are considerable, and their use would, therefore, be very inconvenient.

REPORT ON ELECTRIC LIGHTING.

Vestry of Chelsea.

This report, to which we referred in our last issue, and which is signed by the surveyor of the vestry, Mr. Geo. H. Stayton, Assoc. M. Inst. C.E., and dated Nov. 14, has been published in pamphlet form, and is of considerable interest. A considerable portion of the report is occupied in discussing the various clauses of the Electric Lighting Act, the main objection to which, in respect to present action, is summed up at page 14 as follows:—"It certainly appears most unfortunate that in order to obtain priority of application local authorities are compelled to decide so hastily, and have not been allowed reasonable time to fully consider the subject, and to obtain definite information as to the probable commercial success of such an undertaking." The local authorities, the report goes on to say, "must, therefore, look to the Board of Trade in a great measure for protection against the inconveniences which may arise in consequence of their hands being forced, as it were, by the action of certain speculative companies, who have indiscriminately given notice of application for licenses and provisional orders, not only in the metropolis, but throughout the country."

With a view to obtaining information on various preliminary points necessary to be cleared up before the vestry could be advised to act one way or the other, Mr. Stayton drew up a series of questions to be answered by the several companies who had given notice of their intention to apply for licenses or provisional orders for the lighting of the Chelsea district by electricity. The applicants for licenses by the Board of Trade were from the Metropolitan Brush Electric Light and Power Company and the Jablochkoff Electric Light and Power Company; whilst notices of intention to apply to the Board of Trade for provisional orders had been served on behalf of the Metropolitan Brush Electric Light and Power Company, the Edison Electric Light Company, the Swan United Electric Light Company, the "Pilsen" "Joel" and General Electric Light Company, the Gulcher Electric Light and Power Generator Company, the West Middlesex Electric Light Company, and Messrs. Ferranti, Thompson, and Ince (Limited). To these applicants, and also to Messrs. Siemens Brothers, who, although not applicants themselves, had had considerable experience in electric lighting, Mr. Stayton addressed the following letter:—

Electric Lighting.

Vestry Hall, King's-road, S.W., Oct. 12, 1882.

Dear Sirs: I am instructed to further report upon this question with special reference to the various notices which have been given to the vestry under Sections 3 and 4 of the Electric Lighting Act. I send you herewith a map of this parish, and I may mention that it contains about 40 miles of streets and 12,000 houses. The existing street lighting is effected by 1,250 gas lamps, at an annual cost of £4,500, the price of gas being 3s. per thousand cubic feet. I shall be obliged if you will be so good as to answer the following questions as far as possible at your earliest convenience.

From eight of the companies so applied to Mr. Stayton obtained answers. The Gulcher Company and the "Pilsen" "Joel" declined to proceed with their applications, whilst from the West Middlesex Company no acknowledgment was received.

Commenting on these answers the surveyor to the vestry observes that "whether from indifference or inability" on the part of the companies he is unable to say, "but the result of the inquiries is undoubtedly disappointing, as many of the answers are very indefinite or incomplete. None of the companies have definitely touched upon the question of first cost, but I am of opinion that the probable cost of a complete and efficient installation for the entire area of Chelsea (exclusive of the outlying district of Kensal New Town) would be £375,000. To further consider such a question is totally unnecessary; but to bring the question within a more practical sphere, I have prepared an approximate estimate of an installation in the most suitable parts of Chelsea, based upon the particulars supplied by the evidence of Dr. Siemens, Dr. Hopkinson, Mr. Johnson, Mr. Crompton, and from other and more recent information, which may be summarised as follows, viz.:—

"Estimate for completing an installation of 21,000 'incandescent' lamps for the 1,400 houses, shops, and public buildings, and 120 'arc' lamps for six miles of street lighting, in King's-road, Sloane-square, Sloane-street, Cadogan-place, Cadogan-square, Pont-street, Lowndes-square, Hans-place, Oakley-street, Chelsea Embankment, Beaufort-street, Elm Park-road, Elm Park-gardens, and Fulham-road.

Land, buildings, offices, &c., for two electric stations	£15,000
Engines and dynamos (2,200 h.-p.)	28,000
Fixing and installing	3,000
Conductors (8¼) miles)	25,000
Service and meters (1,400)	5,500
Preliminary expenses and contingencies	8,500
Total	£85,000

"(c) The only definite proposition as to price for the supply of electricity that I am aware of is that of the Metropolitan Brush Company, who consider that 'about 6d. per 1,000 erg-hours of electricity' is desirable. This price worked out and compared with gas at 3s. per thousand cubic feet, is about double.

"N.B.—An erg-hour represents an amount of energy exerted equal to $\frac{1}{746}$th part of a horse-power.

"The probable annual working cost of the minor installation I have described would be from £18,000 to £20,000, irrespective of interest and repayment of capital, and renewals. The estimated annual amount now paid for consumption of gas in the area mentioned (allowing £10 per house) is £14,300; and if the foregoing figures are at all reliable, it is manifest that a profit could not be made except at a charge greatly in excess of gas, *even if all the houses took a supply of electricity*, which, of course, is extremely doubtful."

Mr. Stayton concludes his report by an expression of opinion that although gas has done good service in the past, and will continue in use both as an illuminant and heating power, it will be gradually superseded by the electric light. For the present, however, he does not advise the vestry over which he is surveyor to embark in any venturous changes on its own responsibility, especially as there are companies prepared to undertake the experiments without risk to the ratepayers. He recommended the vestry not to apply either for a license or a provisional order, but to support the application of any company who may appear most likely to carry out such undertaking in a satisfactory manner, and who will agree to any conditions suggested by the vestry and approved by the Board of Trade. These recommendations, as stated in our last issue, were unanimously approved and adopted by the Chelsea vestry last Tuesday week.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending December 8 were £2,526, after deducting the "fifth" of the gross receipts payable to the London Platino Brazilian Telegraph Company (Limited).

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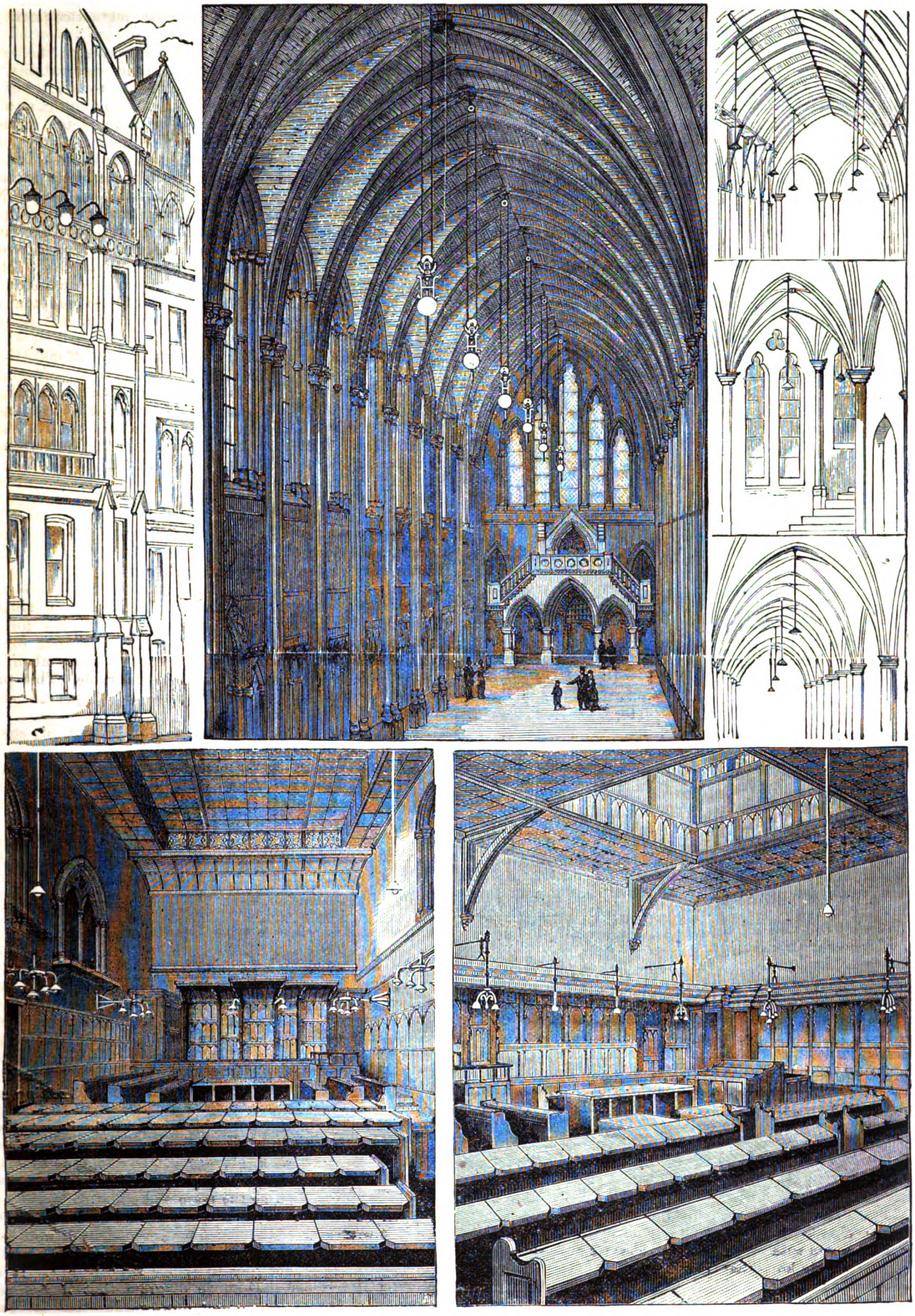
THE ELECTRIC LIGHT AT THE NEW LAW COURTS.



We this week illustrate the interior, as seen on the day of the formal opening by the Queen, of the new Law Courts. Our illustrations show the large hall lighted by six arc lamps, but these are to be replaced by clusters of incandescent lamps.

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Below this two courts are represented lighted by Swan lamps, the side sketches showing, on the left, the arc lamps lighting the Quadrangle; on the right, the bar corridor, the staircase, and the crypt. As we have previously said, the arc lamps were used temporarily, and will be replaced by clusters of incandescent lamps. The illustrations given to-day will show the general arrangement of the lamps, the style of fitting adopted, while future illustrations will give other details.

CROMPTON'S COMPOUND MACHINE.

BY GISBERT KAPP.

Early last spring the writer was engaged in carrying out a series of experiments with shunt-wound Bürgin dynamos, and in discussing the results obtained with Mr. Crompton, the question was considered whether, by the combined use of shunt and main coils, it would not be possible to make a machine, the external current from which would, within reasonable limits, be an exactly pre-determined function of the external resistance. The choice of this function would, of course, depend upon the purpose for which the machine was intended.

If, for instance, it were required that the current should vary inversely as the resistance, a certain definite proportion of shunt and main coils would have to be used, and the machine would be suitable for working at constant speed a varying number of incandescence lamps in multiple arc.

If, again, it were desired to make the current within certain limits independent of the resistance, another proportion of shunt and main coils would have to be used, and the machine would be suitable for feeding a varying number of arc lights in series.

These are the two extreme cases of greatest practical value for electric lighting, but it is quite possible to design machines which will, within reasonable limits, satisfy any other function between current and resistance, and thus be suited to a variety of other than lighting purposes.

After carefully considering this question, Mr. Crompton decided to test the soundness of the principle by applying it to one special case, viz., that of the external current varying inversely as the external resistance.

For this purpose a series of exhaustive experiments were carried out which ultimately resulted in the production of the Crompton-Bürgin compound dynamo, a machine intended to maintain a constant electromotive force in the outer circuit.

My attention was lately called to an article by M. Hospitalier, which appeared in No. 20 of the French paper, *L'Electricien*, and in which the idea of obtaining a constant E.M.F. by the combined use of shunt and main coils was foreshadowed; and quite recently other writers on electrical matters have touched upon the subject, but with the exception of Messrs. Crompton and Co., no makers of dynamo machines in England seem to have brought the matter to a practical issue, the reason for this, perhaps, being that, in electricity, like in other engineering problems, general ideas alone are not sufficient to make a successful invention. They must be supplemented by a good share of practical detail, only obtainable through exhaustive and careful experiments.

The want of some sort of automatic apparatus which would regulate the current to the number of lamps in circuit has long been felt, and several electro-mechanical devices have been invented and added to ordinary machines with a view of making them suitable for this class of work. But if it be remembered that any kind of exterior regulator can only begin to act after the disturbance, which it is intended to avoid, has already commenced to take place, and that even the most delicate mechanical contrivance must necessarily be clumsy and sluggish in comparison with the lightening speed with which electrical charges are propagated, there seems little hope that regulation can ever be obtained by such means. Yet the electro-mechanical regulator should not altogether be discarded; its proper place should be to assist the centrifugal governor of the engine in keeping the right speed. It will be shown further on that even the regulation of Crompton's compound machine, although perfectly sufficient to protect the lamps from injury, and giving them a current which is constant enough for most cases, is not mathematically perfect over the whole range for which the machine is designed, and therefore it is desirable to have an apparatus which will vary the speed of the engines, so as to make the regulation mathematically perfect. It will be shown further on that this variation need in most cases not exceed from 4 to 6 per cent. up or down from the mean speed.

As far as our present knowledge permits us to judge, the solution of the problem how to work incandescence installations seems to be the following: Employ machines which are as much as possible self-regulating, and make up for any slight deficiency in their regulating power by an electro-mechanical governor, which should assist the usual engine governor or take its place.

Before entering into a theory of compound machines and the rules for their design, it will be useful to consider in a general way their principle and mode of action.

In any self-exciting dynamo working in a closed circuit we have to distinguish between four different electromotive forces.

First, that inside the armature $E\,a$; secondly, that at the brushes $E\,b$; thirdly, that at the terminals of the machine $E\,t$; and finally, that between the two main leads $E\,l$ at the point where the external work is done. If the leads are very short, and of ample section, then $E\,l = E\,t$, but generally speaking we have

$$E\,a > E\,b > E\,t > E\,l.$$

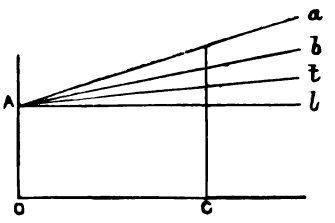
In a given dynamo and circuit the difference between either two of these quantities will vary directly as the current. Now, a perfectly self-regulating machine ought to keep $E\,l$ constant, and this necessitates that $E\,a$, that is, the total electromotive force of the machine, should be a function of the current of the form

$$E\,a = E\,l + e\,C,$$

where C is the current, and e a co-efficient depending upon machine and leads.

This can be shown graphically.

Plotting currents on the horizontal, and the corresponding electromotive forces on vertical lines, we get a diagram like the annexed:—



$O\,A = E\,l$ is the desired constant electromotive force at the chosen point between main leads.

$A\,l$ must, therefore, be a horizontal line.

The electromotive force at machine terminals is now determined by the inclined line $A\,t$, and the tangent of inclination equals resistance of main leads. Similarly the electromotive force at the brushes is given by the inclined line $A\,b$, and the tangent of the angle $b\,A\,l$ equals resistance of exciting coils + resistance of leads.

The total electromotive force is given by the line $A\,a$, and the tangent of angle $a\,A\,l$ equals total resistance of machine + leads.

In the last issue of this paper Mr. Bosanquet gives a formula for proportioning the main and shunt coils.

I shall show later on that this formula is incorrect, but even if it were correct the machine designed by it would not be a self-regulating one, inasmuch as the condition aimed at is to keep the total electromotive force $E\,a$ constant. It will easily be seen from the above diagram that if $A\,a$ be a horizontal, $A\,l$ must be sloping downwards—that is to say the external electromotive force between main leads decreases with an increasing current. The problem is not to keep the

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electromotive force in the armature constant, but that which is available for outside work, and, inasmuch, as it is impossible to make a machine which has absolutely no resistance, the problem can only be solved by arranging matters so that the electromotive force in the armature rises as the current increases. But the solution will be the easier the lower the resistance of machine and leads.

It was shown above that for perfect regulation A a should be a straight line, but experience and theory teach that this line is always gently curved, and this is the reason why the compound machine is not a mathematically perfect regulator over the whole range of current for which it can be used. If the regulation be required within such limits that the curve can be considered coincident with its tangent, then it will be perfect; beyond these limits, the slight variation in speed mentioned above will be necessary to make it mathematically perfect.

(TO BE CONTINUED.)

ON THE HEATING OF COILS THROUGH WHICH ELECTRIC CURRENTS ARE FLOWING.

BY PROFESSOR G. FORBES.

I have already published the law connecting the strength of current which is permissible in wire coils of equal size and weight when these are wound with wires of different thicknesses. We now require the law when the size of the coils is varied. The problem is as follows:—*Two bobbins of similar proportions have their linear dimensions in the ratio of* n : 1, *and the thickness of wire on the two bobbins is also in the ratio of* n : 1. *What ratio of currents is required so as to raise both to the same temperature?*

Let C, R, H be the current in the smallest coil, the resistance of that coil, and the heat generated in that coil.

Let C′, R′, H′ represent the same for the coil of n-fold dimensions.

Then we have

$$C^2 R = H \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$C'^2 R' = H' \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$R' = \frac{R}{n} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Also, since the temperatures are equal, the heat radiated and conducted in the two cases is in the proportion of their surfaces, *i.e.*, of n^2 : 1. And the heat radiated and conducted is equal to the heat generated. Hence from (1) and (2)

$$H' = n^2 H$$

and $$C'^2 R' = n^2 C^2 R$$

or (by (3)) $$C'^2 \frac{R}{n} = n^2 C^2 R$$

$$\therefore C'^2 = n^3 C^2$$

and $$C' = n^{\frac{3}{2}} C$$

To test the accuracy of this law Mr. Robert Goodwin has made the following experiments for me:—Coils of wire were wound upon two bobbins, whose dimensions are

Small Coil.—Length = 50mm., diameter of tube = 13mm., diameter of wire = 1·05mm.

Large Coil.—Length = 100mm., diameter of tube = 25·7mm., diameter of wire = 2·09mm.

The temperature was in each case raised to 63° Cent. According to the above theory the currents should be in the proportion of $2^{\frac{3}{2}}$: 1 or 2·83 : 1.

At the temperature of 63° Cent. the tangent galvanometer showed a deflection of 37° with the small coil, and at the same temperature with the large coil the deflection was 64°. The tangents of these angles are 0·75355, and 2·0503 respectively, the ratio of which is 2·72 : 1, which agrees very closely with the theoretical value.

THE CHERTEMPS-DANDEU DYNAMO MACHINE.

A number of machines are now being introduced to the public, and it is hoped by each inventor that his machine will prove generally better than those of his competitors. We, together with other gentlemen interested in electrical progress, have been invited to see the dynamo known as the Chertemps-Dandeu at work. It is impossible to do more than obtain general impressions by seeing a machine at work. In order to obtain a comparative value for a machine it is necessary to carry out a series of experiments, and to very carefully collate the result with those obtained from other machines. Before describing the construction of this machine we may give the reports of Mr. Robert Sabine's investigations. These reports are addressed to R. Applegarth, Esq., whose name is well known to those interested in electric light work, and who has introduced this machine into England:—

"I have examined the dynamo electric machine of Messrs. Chertemps and Dandeu with the following results. I found the machine, which is designed to sustain ten Jablochkoff lamps, to be very compact and well made. It is on the alternative current principle, and self-magnetising. Its conducting coils are made to rotate, while those of the induced circuit are stationary, an arrangement which greatly facilitates any necessary supervision or manipulation of the main circuit while the machine is in motion. The supporting frame of the induced bobbins is constructed entirely of insulating material for the purpose of avoiding the development of the so-called Foucault currents; and this is unquestionably a means of saving engine-power, and working the machine more economically than would otherwise be the case.

"Phonometric measurements were made with two up to eight Jablochkoff lamps in circuit, when the machine was driven by a four (nominal) horse-power steam engine, of which indicator diagrams were simultaneously taken, and it was found that the power expended in the machine short leads and lamps increased as follows:—

Lamps on Circuit.	Engine-power Expended on Machine Leads and Lamps.	Speed of Machine.
2	1·28 h.-p.	1150 rev. per minute.
4	2·27 h.-p.	
6	3·60 h.-p.	
8	4·25 h.-p.	

"The average illuminating power of the lamps was 323 standard candles (actual) during these measurements.

"Similar measurements with 10 Jablochkoff lamps and upwards in the circuit were made with the aid of a 20 (nominal) horse-power steam engine, which enabled a greater velocity of rotation to be steadily maintained.

"When 10 lamps were in circuit, the machine being driven at 1,226 revolutions per minute, the engine-power expended in machine, leads, and lamps, was 5·65 horse-power, the average illuminating power per lamp being 430 standard candles (actual), or an effective equivalent of 762 standard candles (actual) per horse-power expended, which is as high as can be expected for a small machine.

"The light given by the lamps was remarkably steady, and the carbon rods were consumed very uniformly.

"At the desire of the inventors, as many as 16 Jablochkoff lamps were at one time introduced into the circuit, and burnt steadily. While 14 lamps were burning, the average illuminating power was found to be 388 standard candles per lamp. The machine after being at work for two hours did not show any signs of heating so long as the number of lamps did not exceed 10, but when 16 lamps were sustained the stationary induced magnets became after a while heated, the rest of the machine and the moving bobbins remaining cold. I conclude from this that not more than 12 Jablochkoff lamps, each giving a light of about 400 standard candles (actual), could be safely worked continuously by this little machine.

"The commutator which directs the currents from one of the stationary electro-magnets into the magnetising circuit works against the brushes perfectly free from sparks.

"In the foregoing tests the coils of the machine and the lamps in circuit were connected up in series.

"The terminals of the machine are, however, arranged so that the current of each induced bobbin may, if required, be connected so as to actuate a separate and independent lamp circuit.

"A very ingenious arrangement is employed for short-circuiting each of the induced bobbins by the armature of a small electro-magnet, which falls upon the terminal blocks in the event of a rupture of the outer lamp circuit.

"In point of cost, I should say that this machine would cer-

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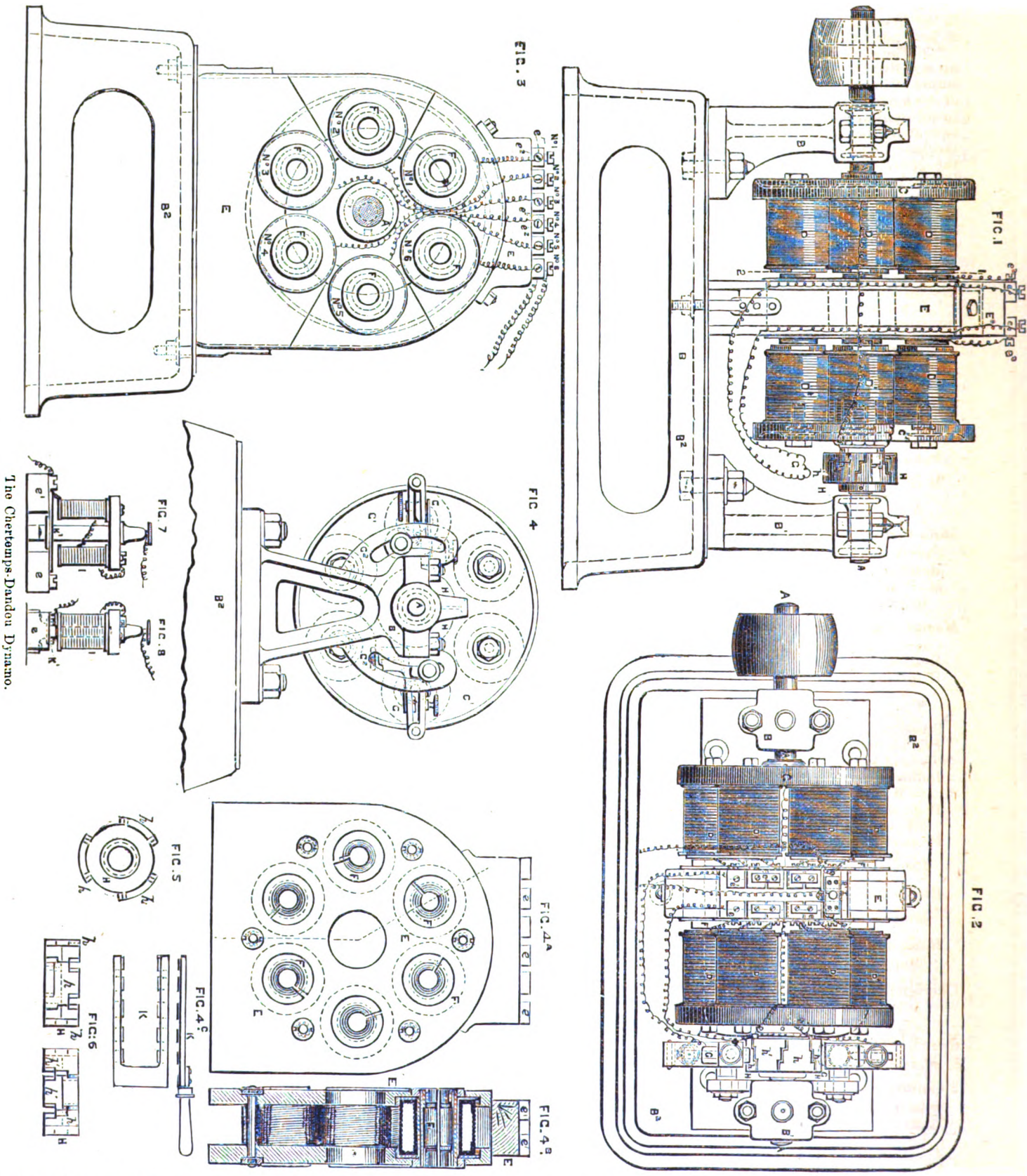
tainly be the cheapest I have seen capable of keeping an equal number of lamps in action, and I quite endorse the inventor's statement that it might be produced and sold at a price which would leave a very good margin of profit.—Yours, &c.,

(Signed) "ROBERT SABINE."

The Chertemps-Dandon Dynamo.



Second report on the Chertemps dynamo machines :—

"I have at your request tested two of the Chertemps machines which you have at Charles-street, Hatton-garden.

"In reply to the questions asked in your letter to me of the 24th November, I beg to say that—

"1. I find that the smallest machine (alternating current) keeps 20 Edison A 16 candle lamps incandescent at an expenditure of about 2 horse-power, as indicated by M. Morin's dynamometer, which is placed between the steam engine and the machine.

"The maximum number of lamps which I saw in circuit at one time was 25, which number was then reduced by five at a time. The horse-power indicated by the dynamometer fell each time proportionally to the number of lamps removed from the circuit.

"2. The medium-sized machine, when giving alternate currents with its induced bobbins parallel, was put in circuit with 52 Edison A lamps, which were kept incandescent at an average

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of 17·5 candles, with an expenditure of 6·2 horse-power indicated by the dynamometer. The machine was afterwards connected up so as to give continuous current, the same number of lamps being kept incandescent at an average of 15·1 candles per lamp, while the indicated horse-power was 5·1, showing that in so far as lighting power goes circuits with alternate and continuous currents generated by the same machine give much the same result. In each instance over 80 per cent. of the power given to the dynamo machine was accounted for electrically, and over 65 per cent. was accounted for in the lamps alone.

"3. The same machine, with its induced bobbins in series, and giving alternate currents, was then connected with and kept in action 10 Jablochkoff lamps, also in series, at a total expenditure of 4·9 horse-power indicated by the dynamometer as being given to the dynamo machine. The number of lamps was changed by two at a time, and the difference of the power given to the machine being observed at the dynamometer, it was seen that the power employed was always proportional to the number of lamps in circuit, the machine regulating this automatically. When maintaining the Jablochkoff lamps about 80 per cent. of the power given to the dynamo was accounted for electrically, and with over four lamps in circuit about 65 per cent. was accounted for in the lamps alone.

"I consider that, having regard to their size and weight, the efficiency of these dynamo machines, both for arc and incandescent lamps, is very satisfactory.

"I enclose the details of the tests made with the larger of the two machines.—Yours, &c., "ROBERT SABINE."

Chertemps (medium-sized) machine tested with 52 Edison A lamps (French made) connected parallel with short leads :—

	Alternate current.	Continuous current.
Main Circuit (external):*		
Current per lamp	0·68	0·66
Do. for 52 lamps = c = ...	35·4	31·3
Potential-difference = e = ...	85	83
H.-P. accounted for in 52 lamps = $\frac{c\,e}{746}$ = W = ...	4·03	3·48
Main Circuit (internal):		
Current (as before) = c = ...	35·4	31·3
Resistance of 5 bobbins parallel = r = ...	0·3	0·3
H.-P. accounted for in internal wire ..... = $\frac{r\,c^2}{746}$ = W_1 ...	0·50	0·39
Magnetising Circuit:		
Current in magnetising circuit = c_1	6·5	6·5
Resistance in ditto = r_1	7·4	7·4
H.-p. accounted for in this amount = $\frac{r_1 c_1^2}{746}$ = W_2	0·42	0·42
Speed of dynamo—rev. per min.	1180	1174
Pull on dynamo = K = ...	49kilog.	45kilog.
Speed of dynamometer—rev. per min. : S :	662	648
Indicated h.-p. = $3·21 \times 10^{-4}$ S (K − 20) = W_0	6·2	5·1
H.-p. accounted for electrically ($W + W_1 + W_2$) = ...	4·95	4·29
Proportion of h.-p. electrically accounted for $\frac{W + W_1 + W_2}{W}$ = ...	0·80	0·84
Proportion of h.-p. accounted for in lamps alone $\frac{W}{W_0}$ = ...	0·65	0·68
Horizontal (front) candle-power of one lamp (average)	17·5	15·1

Chertemps (medium-sized) dynamo-machine tested with Jablochkoff candles connected in series.

No. of Lamps in circuit = n = ...	10	8	6	4	2
I. *Main Circuit.*					
Current in amperes = c = ...	5·5	5·5	5·3	5·0	5·0
Internal resistance in ohms = r =	7·3	7·3	7·3	7·3	7·3
H.-p. accounted for internally... = $\frac{C^2 r}{746}$ = W =	0·30	0·30	0·27	0·24	0·24
External potential, difference of lamps, volts = E = ...	430	344	258	168	88
H.-p. accounted for in lamps... = $\frac{E\,C}{746}$ = W_1 =	3·16	2·53	1·93	1·15	0·60
II. *Magnetising (Field) Circuit.*					
Current (amperes) = c_1	5·4	5·0	4·6	4·1	3·7
Resistance of wire (ohms) = r_1 ...	7·4	7·4	7·4	7·4	7·4
H.-p. accounted for in field circuit ... = $\frac{c_1^2 r_1}{746}$ = W_2 =	0·29	0·25	0·21	0·17	0·14
Speed of dynamo	1242	1230	1236	1260	1218
Pull on dynamometer in kilog. = K	42	36	32	28	24
Speed of ditto, rev. per min. = S	665	666	678	676	678
Indicated h.-p. = $3·21 \times 10^{-4}$ S (K − 19) = W	4·9	3·7	3·0	2·0	1·2
H.-p. accounted for electrically = $W + W_1 + W_2$ =	3·75	3·08	2·41	1·56	0·98
Proportion of h.-p. electrically accounted for = ...	0·77	0·83	0·81	0·78	0·81
Ditto accounted for in lamps = ...	0·64	0·68	0·64	0·57	0·50
Horizontal front candle-power of one lamp*	289	334	321	308	279

* Current in amperes, E.M.F. in volts, resistance in ohms.

* The carbons in these measurements were apparently of inferior quality.

The accompanying figures will almost explain themselves. Figs. 1 and 2 are respectively an elevation and a plan of the dynamo. The shaft A is mounted in plummer blocks, B B, secured to the base B_2. The shaft carries a pair of cast-iron discs, C C^1, to which, and inside the field, hollow electro-magnets D are fixed. Between the field magnets is the armature, which is stationary, composed of non-conducting material, E and pierced with a ring of holes. The axis of the ring of holes corresponds with the axis of the field magnets, and the diameter is such as to arrange for the armature magnets to be opposite the field magnets as these latter rotate. The armature coils fit into these holes, and consist of a hollow core of iron tubes wound with wire, as shown in section in Fig. 4*b*. The armature carries six of these coils (Fig. 3) and the connections made, as shown, to terminals carried by an insulating block E*. Figs. 4*a* and 4*b* show one way of arranging this block. One pair of wires thus brought to the terminals lead to the field magnet coils, and the current in this wire excites the field magnets. The other wires are used in series, or as required in the external circuit. The current for the field magnets passes through a commutator, H, and brushes, as shown. Figs. 5 and 6 show the parts *h h* of the commutator used to transform the alternate into continuous currents.

In order to provide exciting currents for the field magnets proportionate to the requirements of the bobbins, from which the currents are to be taken for illuminating or other purposes, the exciting bobbin which is connected with the brushes or rubbers H is coiled with wire of a gauge corresponding to the gauge of the wire on the field magnets, and the weight of this coil is made to correspond with the weight of the other bobbin coils of the armature. The conducting wires through which the exciting currents are passed to the field magnets are also made of equal gauge. By this means induced currents are passed into the field in the exact proportion required to give full efficiency to the field magnets.

In order to combine together two or more currents of the working circuits according to the work in hand, there is a forked sliding piece K (Fig. 4*c*), made to under-run the terminal screws fitted to the several blocks, and thereby to couple them up as required.

To avoid heating the armature, should the circuit be accidentally broken, a small electro-magnet (Figs. 7 and 8) is mounted on the fixed armature *e e'*. When the current passes normally into the lamp circuit the armature of this magnet is raised, but should the current, cease the armature falls and makes the contact necessary for its renewal.

THE TRANSMISSION OF POWER BY ELECTRICITY.*

BY LL. B. ATKINSON, ESQ.

(CONTINUED FROM PAGE 91.)

ERRATA.—In estimating the kinetic energy of water in the pipe ·25 should read ·166. In reducing the formula $\frac{1}{2} m v^2$, there is an error in the place of the decimal point. The final answer, instead of 14·7, should read ·066.

I think it will be best for me here just to apply these general remarks to the case of one machine. I shall choose the Gramme,

* A Paper read before the King's College Engineering Society. Printed by permission.

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because I consider it the simplest, whilst it is typical of all others.

I have shown, in Figure 4, the principal parts of this machine. We have two magnet poles, north and south; between the curved ends of these there is an axle on which is mounted an iron ring, the iron being as soft as possible. This ring is wound with about eighty coils of wire, all continuous. In the diagram I have shown only one layer of wire; in reality it forms several layers. At intervals round the ring the insulating material is scraped off, and a short piece of wire soldered on. Each of these short pieces is brought to a separate slip of copper on the commutator, each strip being carefully insulated from its neighbour. There are generally about eighty slips, whereas for the sake of clearness I have only shown eight.

Now suppose the ring rotated in the direction of the arrow.

It will be seen that as any individual coil leaves the point A, more and more of the lines of force which proceed from one pole to the other, round by the iron ring, pass through the coil

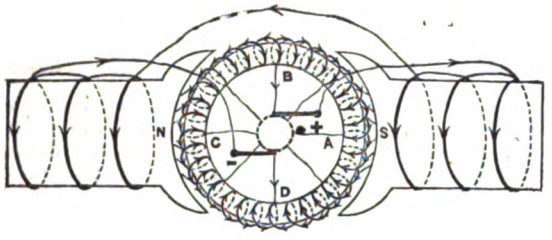

FIG. 4.

The effect of this will be to produce a current in the direction shown by the arrows on the coil. When the coil arrives at B it begins then to lose some of the lines passing through it; the effect is to produce a current, but in the opposite direction to that produced by the addition of lines, so here the current is reversed. We might follow the coil right round, but the action in the other half is precisely analogous, but inverted. Now, if we look at the arrows, we see that the currents in the two halves of the ring both proceed from D and meet at A. The result is that they make use of the short wires at these points to run down to the commutator slips, against which press metallic combs or brushes, connected with the exterior circuit. Owing to the number of strips there is always a strip in position to take off the current, and hence the action is continuous.

The direction of the current produced in any coil is, by Lenz's law, always in such a direction as to oppose the motion by its attraction or repulsion of the magnetic pole. Supposing the machine to have electro-magnets, we must allow the current pro-

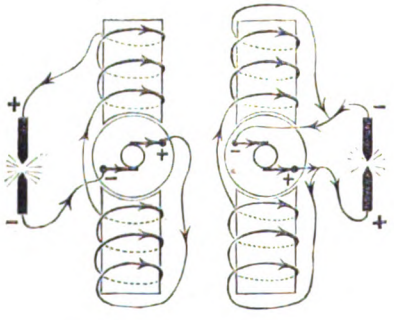

FIG. 5.

FIG. 6.

duced by the machine to circulate round the magnets. There are two methods of doing so.

Either the whole current passes through the magnets and then to the exterior circuit, lamp, motor, or whatever it may be, in which case the machine is called a series dynamo, or it branches on leaving the brushes into two separate circuits; part goes at once to the exterior circuit, whilst part is wholly occupied in keeping the magnets magnetised, in which case the machine is called a shunted dynamo (Figs. 5 and 6). Both methods have particular advantages for certain cases.

In order to transmit power by electricity we must have the following things:—1st. A source of power, as steam, water, wind, or whatever it may be; 2nd. An electric generator, or dynamo electric machine; 3rd. A conductor for the electricity between the two points; 4th. A receiver of power, either a motor or accumulators.

I shall not speak of the source. I shall suppose we have settled on some source of power.

We produce our electricity by a dynamo, preferably a shunted one, for reasons which will presently appear. At the other end we have our receiver, which I shall suppose a motor.

Every dynamo electric machine will, if a current be passed into it in the same direction as the current it produces when running flows, begin to revolve backwards and act as a motor. This is a consequence of what is known as Maxwell's rule, which states, "That any coil carrying a current will tend to place itself so that as many lines of force as possible are enclosed by it." Up to the present time all our motors have been dynamos thus reversed, though special motors are now being designed.

Every generator will act as a motor, but every motor will not act as a generator, though many will.

We can apply this motor to actuate any machinery we like, and hence we have here a true transmission of power. At one end we have our prime mover, at the other the electromoter giving out the power, or part of the power put into the whole system by the prime mover.

Now let us examine a little more closely into these individual parts. Of the power put in by the prime mover, a dynamo will give out nearly 90 per cent. electrically. To estimate the h.-p. given out electrically by any generator, we multiply the electromotive force in volts by the current produced, measured in amperes, and multiply the product by ·00134. This is the actual h.-p. given by the machine to the wire. Now, in going through the wire a certain part of this is lost, since a current passing through a wire always heats it, and heat means loss of energy, so rather less than this amount arrives at the other end. Here we have seen that the current sets the dynamo in motion, but we have seen that a dynamo in motion produces a current, and this current is in the opposite direction to that producing the motion. The effect is that the moment the motion commences the current is weakened. The electromotive force set up in the machine in opposition to the elecromotive force of the distant generator is called the back electromotive force. Now, curious as it may seem, if it were not for this back electromotive force, we could turn no part of our electrical energy into mechanical work. The only part of the energy which enters the machine, which produces any useful effect, is that part which is forced through the machine against the back electromotive force, all the rest merely serves to heat the machine. Suppose we send a current of A amperes through any conductor of R ohms resistance, the h.-p wasted in heat is

$$A^2 \times R \times \cdot00134.$$

Now, this would hold good just as much for the current passed into the dynamo as for any other case, and if the current is thus producing heat, it cannot produce mechanical work at the same time; but if we pass a current of A amperes through a machine of resistance R, and which is producing a back electromotive force e, the useful work in h.-p.,

$$e \times A \times \cdot00134,$$

the waste is $A^2 \times R \times \cdot00134$;

so the higher we make e the less is the loss in the machine.

Now let us look at the whole transmission similarly.

The generator produces an electromotive force E.

The motor produces a back electromotive force e. The electromotive force which will produce a curent is E − e the difference.

By Ohm's law, as I explained, the current is

$$\frac{E - e}{R} = A.$$

Now, the whole work given out by the generator is

$$A \times E = \frac{E - e}{R} \times E.$$

The work put into the motor we may, for the moment, assume to be equal to this. It will be rather less, in fact, if any considerable distance separates them. The useful work, that is, mechanical effect, of the motor is, as I just now showed,

$$A \times e = \frac{E - e}{R} \times e.$$

Now, in order that the transmission should be as efficient as possible, that is, that as large a proportion as possible of the work put in should be given out, we must make the following fraction have its greatest value:—

$$\frac{\frac{E - e}{R} \times e}{\frac{E - e}{R} \times E}.$$

We shall get the greatest value for this fraction when e is nearly equal to E.

If e nearly equals E, $\frac{E - e}{R}$ will be very small, but if E and e are themselves large absolutely, we can transmit any amount

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of power we like. So in order to transmit power economically and efficiently by means of electricity we must use machines of very high electromotive force, and in this comparatively simple calculation lies the basis of the whole solution to the problem, as, I believe, was first pointed out by Professors Ayrton and Perry. Now, the conductor between two points must generally be of copper, which is very expensive, and hence we must use as small a wire as possible. Let us first see what is the smallest wire we can possibly use safely, without its getting too hot, then we shall see what is the *best* wire to use.

Let us suppose the wire to be hung in the air so as to have free access to the air and free radiation. We know from Newton's law that the amount of heat radiated where A = area, θ = temp. above air, is $\propto A \times x \times \theta$, or more generally the following law, due to Dulong and Petit.

$$m \times 1{\cdot}0077^{t} (1{\cdot}007^{T} - 1) \times A.$$

This gives the loss of heat per hour from a surface A square feet, when $T - t$ is the difference of temperature between the heated body and surrounding bodies, and t is the temperature of surrounding bodies, m is a constant differing for different materials. For copper its value is about 3·3.

It would not be wise to allow the wire to become hotter than 150deg. F. The temperature of the air averages about 55deg., so the difference of temperature between the air and the wire = 95deg. F = 35deg. C.

This calculation was inserted, not on account of any importance which I attach to the result, but rather to show the points on which such a calculation depend.

Formula for the minimum size of wire for any current.

$$\left.\begin{aligned} & 1{\cdot}0077^{t} (1{\cdot}0077^{T-t} - 1) \times m \\ &= 1{\cdot}0077^{12-7} (1{\cdot}0077^{35} - 1) \times m \\ &= 12{\cdot}7 \times {\cdot}0033313 (35 \times 0033313 - 1) \times m \\ & \quad {\cdot}04230751 ({\cdot}1165955 - 1) \times m \\ &= {\cdot}04230751 (1{\cdot}3079 - 1) \\ & \quad ({\cdot}13070) \\ &= {\cdot}0423075 + T\,{\cdot}4884097 = T{\cdot}5307172 \times m \end{aligned}\right\} \text{Calculation by logs.}$$

$= {\cdot}3394 \times 3{\cdot}31 = 1{\cdot}1233$ units of heat per foot surface per hour (pound water centigrade units)

The surface of a wire in sq. feet when l = length in miles d = diameter in inches

$$= \pi d \times l \times 5280 = \pi dl \times 440 = dl \times 1382{\cdot}3 \text{ sq. feet.}$$

The heat generated in any wire is $C^2 R \times \frac{1}{4{\cdot}2} = C^2 \times \frac{l}{20d^2} \times \frac{1}{4{\cdot}2} = \frac{C^2 \times l}{d^2} \times {\cdot}0119$ (gramme water centigrade units) per sec.

Since the surface of a wire is $dl \times 1382{\cdot}3$ sq. feet, the heat radiated is $1{\cdot}1233 \times 1382{\cdot}3 \times dl$ (pound water centigrade)

$$= {\cdot}0504958 + 3{\cdot}1910981$$
$$= 3{\cdot}1910981$$
$$= 1553{\cdot}7 \times dl \text{ units (lb. } H_2 0.C^0.)$$

to convert this into (grm. $H_2 0.C^0$) multiply by 453·6

$= 3{\cdot}1910981 + 2{\cdot}6566730 = 5{\cdot}8477711 = 704320$ (grm. $H_2 0.C^0$) per hour,

so heat generated is $\frac{C^2 \times l}{d^2} \times {\cdot}0119$ units per sec.

Heat radiated is $dl \times 704320$ per hour $= dl \times 195{\cdot}6$ per sec. And for the temperature to be constant these two must be equal.

$$\therefore \frac{C^2 \times l}{d^2} \times {\cdot}0119 = dl \times 195{\cdot}6 \therefore d^3 = \frac{C^2 \times {\cdot}0119}{195{\cdot}6}$$

$$d^3 = \frac{{\cdot}0119}{195{\cdot}6} = C^2 = {\cdot}000060838\ C^2$$

$$\therefore d = {\cdot}034364 \sqrt[3]{C^2}$$

Where d = diameter of wire. This is only strictly true in vacuo, in air about 50 to 100 per cent. more dissipation of heat will result.

We have now seen what is the possible limit to the thinness of the wire, but it does not follow that the *best* wire is of necessity the smallest. There are two considerations. If the wire be small we waste a considerable amount of power in heating the wire, and, if the power costs much, this will be an expensive item.

On the other hand, if we make the wire large we sink a considerable capital outlay, and hence we are losing the interest on this capital. In any case we lose something in wasted power, something in capital sunk. We must try to make the sum of these two losses as small as possible.

It is evident that a very considerable element in the calculation is the cost of power. If we use steam it may be expensive, if we use a waterfall the power costs next to nothing, and we do not care particularly how much we lose, and we then should use the smallest practicable wire, as I before explained.

Without going into the details of the calculation, I will give a general formula for the best size of wire for transmission of any amount of power at any cost per horse-power. The price of copper assumed is £70 per ton, and 5 per cent. interest allowed on capital outlay.

If cost of copper is not £70, we can alter this by remembering that the area is proportional to

$$\frac{1}{\sqrt{\text{cost of copper}}}.$$

The formula given by Sir W. Thomson at the York meeting of the British Association is $A = C\sqrt{\frac{e}{1{\cdot}38}}$, where A is area in centimetres, C is the current, $e \times$ £10 is the actual cost of a horse-power per year.

I have explained how essential to economical transmission is the use of high electromotive forces. Now, though this may seem simple, it involves various inconveniences. First, it would be fatal to touch the wires, thus completing the circuit; second, it makes the insulation of the line difficult. The second difficulty can be overcome by using insulating materials of very high quality, and putting the line up with great care. The first of these disadvantages makes it necessary that the power transmitted should not be at once used to light houses, work factory machinery, &c., where it would be used by ignorant persons; but that it should be received at a station, and converted into electric power, with a lower electromotive force. There are two ways of doing this. We may receive the power into a primary motor, which motor shall drive dynamos furnishing a lower electromotive force and a larger current. Such a system might be worked without much loss. Another way, due to Sir W. Thomson, is to charge accumulators, all arranged in series as Fig. 7.

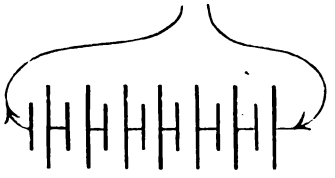

Fig. 7.

Then rearrange in parallel circuit as in Fig. 8, for discharge, the whole quantity of energy given out will be nearly the same, but

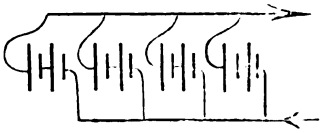

Fig. 8.

at a lower potential. In the one case the work put in will be $n\,E \times Q$. Each cell taking $E \times Q$, if arranged as in 2, the the work given out by each cell is $E \times Q$, therefore each pair will give $2\,E \times Q$, and so the whole set will give

$$2\,E \times \frac{n\,Q}{2} = n\,E\,Q.$$

Some people think this plan the more promising, but whether it can be efficiently done depends on what improvements will be made in secondary batteries.

In charging secondary batteries we have a back electromotive force, and all considerations with respect to the use of a receiving motor hold equally true for accumulators.

As I before stated, the efficiency of the transmission depends on the ratio of the back electromotive force to the primery electromotive force, or the ratio

$$\frac{e}{E}.$$

Since in dynamos and motors the electromotive force is proportional to the speed, that is, if the magnetic field is constant, the efficiency would depend on the ratio of the two speeds,

$$\frac{s}{S}.$$

An interesting experiment has been made at Munich. Power

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is transmitted from Wiesbach to Munich, a distance of about 57 miles. There were used two ordinary telegraphic wires, 4½ millimetres diameter, one as lead and the other as return wire.

The total resistance of the circuit was 1,900 ohms. Two similar machines (Grammes) were used, their resistances being 470 ohms each, the resistance of the line being 960 ohms.

The speed of the first machine was 2,200 revolutions per minute, the speed of the second 1,500 revolutions per minute. From these speeds we should expect the efficiency to be

$$\frac{s}{S} = \frac{1,500}{2,200} = \cdot 67, \text{ or } 67 \text{ per cent.}$$

Actually about 60 per cent. of the energy put in to the wire at one end was got out at the other, the rest being wasted in heating. The amount of power transmitted in this case was not very large, nevertheless it is a case of great interest, owing to the use of ordinary iron telegraph wires.*

Perhaps, now, it will be well to take a few instances, and compare electricity and water, but here it may be remarked that whilst the pressure of water is limited by the weakness of pipes, the possible limit to the electromotive force which may be used is very high indeed.

The efficiency of water transmission is given by the formula

$$M = 1 - k\left\{\frac{E^2 \times l}{p^3 d^5}\right\}$$ where E is the h.-p., put in p the pressure, d the diameter of pipe, l the length.

The efficiency of electric transmission is

$$M = 1 - k\left\{\frac{E \times l}{V^2 \times d^2}\right\}$$ where V is the electromotive force of the generator, d diameter of wire;

k in each case is a constant depending on our units of length, &c.

It will be seen that the transmission of large quantities of power by water means great loss, by electricity not nearly so much, by water the efficiency increases as the cube of the pressure, but then the pressure cannot often be greater than 700lb, whilst the potential V may be as much as 80,000 volts.

Suppose we want to transmit power 10 miles, and we use a 6" pipe and 700lb. pressure, that is the almost highest pressure ever used practically. Then,

If we put in	1,000 h.-p.,	we lose	10 h.-p.
,,	2,000	,,	80 ,,
,,	6,000	,,	640 ,,
,,	8,000	,,	5,120 ,,
,,	10,000	,,	lose all.

Now, electrically, let us transmit 10 miles with a half-inch cable, using earth return; let the potential used be 3,000 volts; let us maintain at the receiving end a potential of, say, 2,000 volts. The resistance of such a line will be nearly 2 ohms.

$$E - e \quad C$$

The h.-p. transmitted $= 3,000 \times 500 \times \cdot 00134 = 2,010$ h.-p.
The h.-p. received at other end $2,000 \times 500 \times \cdot 00134$ 1,340.
The h.-p. lost $= 1,000 \times 500 \times \cdot 00134$ 670.

So, out of 2,010 h.-p., we lose 670 h.-p.

But, suppose we use 40,000 volts over similar conditions, and maintain a potential at the other end of 39,000, the current remains the same.

The h.-p. transmitted is 26,800.
The h.-p. received is 26,130.

The loss is 670 h.-p., just the same as for 2,010. So we may increase the h.-p. transmitted, and lose no more by merely increasing the working potential. This fact cannot be too clearly impressed on the mind. Many systems using a low potential are advertised for lighting and transmission of power; for this purpose they are wholly inadequate. I think now I have given a general notion of the method of action, and the conditions of efficient working in transmission of power by electricity. The advantages of all methods of transmitting power consist in generating power wherever it may be cheaply obtained, as with water power, or by large engines of several thousand horse-power, and then distributing, instead of each consumer working a small and inefficient steam engine himself. Even if we lose 50 per cent. in transmission we should still be the gainers by such a method of working, but I think we may look for a higher yield than this.

I have not entered in this paper into any details as to the best dynamos, the best motors, or anything of this kind, these alone would more than fill a paper; neither have I given any description of the methods of distributing from a central station, over a considerable area. This again would be too wide a subject to begin in the limits of this paper. What I have tried to do is to lay before this society the main bearings of the problem, to show what are the points to aim at, and to show the weak points of the system.

* Since this was written these results have been upset, it having been shown that, using similar machines, the magnetic fields would not be equal.

To sum up the advantages and disadvantages of this system, compared with water and ropes, I think that for work of a somewhat temporary character ropes might be used, but when continued use is contemplated, the expense attending repairs on this system would outweigh its advantages. Wherever we want to transmit a moderate amount of power over moderate distances, particularly for slow moving machinery such as punching or shearing machinery, or for riveting machines, water is at its best, and may advantageously be used.

But when we come to transmit large quantities of power for great or small distances for any rapid moving machinery, or for railways, or for lighting and heating, I think that no system will be found to successfully compete with the transmission of power by electricity.

[The author wishes to state that, having attended Professor Ayrton's lectures on transmission of power, he is indirectly indebted to him for much that is of value in the paper, and indirectly to Professor Perry, who has taken so distinguished a part in reducing the various systems to a *quantitative* comparison. It will be seen that the valuable store of information contained in Professor Perry's recent Cantor Lectures has been largely drawn upon.]

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Dec. 13.		Business Done Week Ending Dec. 13. Highest.	Lowest.
Anglo-American	47½,	48½	48½	48½
Do. Preferred	78½,	79½	80	78
Do. Deferred	17½,	18½	18½	17½
Brazil Submarine	11⅞,	12	11 15-16	11 13-16
Cuba	9½,	10	—	—
Do. Preference	16,	17	—	—
Direct Spanish	6½,	7	7	6⅞
Do. Preference	16,	17	16½	16⅝
Direct United States Cable	11⅜,	11⅝	11 9-16	11⅜
Eastern Telegraph	10⅜,	11⅛	11	10 13-16
Do. 6 per Cent. Preference	13⅜,	13⅞	13½	13⅜
Do. 5 per Cent. Debentures, 1899	103,	106	—	—
Eastern Extension	11⅛,	12⅛	12 1-16	12
German Union	10,	10½	10½	10½
Globe Telegraph and Trust Company.	6½,	6⅝	6⅝	6 7-16
Do. Preference	12½,	12⅞	12 13-16	12⅝
Great Northern	12⅛,	12⅝	12⅝	12⅝
Indo-European	31,	32	31½	31½
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	8	—	—
Reuter's	12½,	12⅝	—	—
Submarine	250,	255	253	253
West India and Panama	1½,	1½	1⅝	1⅝
Do. 1st Preference	7,	7½	7½	6⅝
Western Brazilian	7⅛,	7⅜	7⅜	7⅜
West. Union 7 per Cent. 1st Mortgage	122,	126	125½	122
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	⅜	13-16	11-16
Oriental	⅛,	⅜	⅝	⅝
United Telephone	10½,	11	11⅛	10⅝

ELECTRIC LIGHT.

Brush Light (£4 paid)	7',	8	9½	7 11-16
Do. (fully paid)	15,	18	18½	16⅝
Hammond Light	4,	4½	—	—
Eastern Electric	1½,	2	2	1½
Edison, Joel, and General Electric	1,	1⅛	1⅛	1⅛
Gulcher (£1 10s. paid)	⅜,	½	—	—
Swan	1⅞,	2⅛	2 1-16	2
Maxim-Weston	⅜,	½	½	½

TRAFFIC RECEIPTS FOR NOVEMBER, 1882.

Companies.	Nov., 1882.	Nov., 1881.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	1,600	2,439	—	839
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	54,093	49,829	4,260	—
Great Northern Telegraph Company	20,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SLIP

JAMAICA AND COLON.—The cable between these two places, which was interrupted in the month of September, is now restored.

ELECTRIC LIGHT IN LIBRARIES.—Electric lights have been placed in the main room and newspaper room of the Mercantile Library of Philadelphia.

GREAT NORTHERN TELEGRAPH COMPANY.—This company announce a half-yearly interim dividend at the rate of 5 per cent. per annum, and payable on the 1st of January by Messrs. C. J. Hambro and Son.

UNDERGROUND WIRES IN FRANCE.—The underground cables between Paris, Lille, Nancy, and Dijon, have recently been opened for traffic with success. That between Paris and Lyons is to be opened shortly.

SWAN UNITED ELECTRIC LIGHT COMPANY.—This company have made a call of 10s. per share, payable on the 9th January, 1883. This call is made in order to carry out some important new installations now in hand.

ROYAL SOCIETY.—At the meeting of this society on Thursday, a paper "On the Connection between the State of the Sun's Surface and the Horizontal Intensity of the Earth's Magnetism," was to have been read by Professor Balfour Stewart.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending December 15th, 1882, were £2,732, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

LONDON PLATINO BRAZILIAN TELEGRAPH COMPANY.—The revenue of this company for the month of September, 1882, is estimated at £1,784 (Western Brazilian portion £1,340, land lines £444), as against £1,525 for the corresponding period of 1881.

SOCIETY OF TELEGRAPH ENGINEERS.—The *Journal* of the Society of Telegraph Engineers and of Electricians for December, is wholly, or almost wholly, devoted to Colonel Frank Bolton's paper on "Some Further Historical Notes on the Electric Light," &c.

NEW TELEGRAPH LINES IN FRANCE AND BELGIUM.—It is stated that France and Belgium have arranged to construct telegraph lines along the Sambre, Aisne, Scheldt, and Lys, in order to exchange despatches on any rise of those rivers threatening an inundation.

WEST COAST OF AMERICA TELEGRAPH COMPANY.—The coupons due on the 31st December next on this company's debentures will be paid on the 30th inst., on presentation at their bank, by Messrs. Barclay, Bevan, and Co. Coupons must be left three clear days for examination.

EASTERN AND SOUTH AFRICAN TELEGRAPH COMPANY.—This company notify that the coupons due on January 1st next on their Five per Cent. Mortgage Debentures will be paid on presentation by Messrs. Barclay, Bevan, and Co. Coupons must be left three clear days for examination.

A TELEPHONE CABLE.—News from America says the Southern New England Telephone Company have laid a 21-wire cable across the Thames River, from Winthrop Point to the Groton shore, thereby putting the States of Massachusetts, Connecticut, and Rhode Island on speaking terms.

MAXIM INCANDESCENT LAMPS IN MADRID.—The whole of the house occupied by the Minister of War at Madrid, is lighted by means of Maxim lamps. The current is supplied from the central station of the Sociedad Espagnola de Electricidad, which is situate close by. Gramme machines are used.

NEW LAND LINES.—*The Times'* Paris correspondent, telegraphing on Dec. 18, says:—"France and Portugal are in treaty for a land telegraph between Paris, Bordeaux, and Lisbon, which would be used for communications between northern and central Europe, and South America and West Africa."

EASTERN EXTENSION TELEGRAPH COMPANY.—The directors of the Eastern Extension, Australasia, and China Telegraph Company have declared an interim dividend for the quarter ended 30th September last of 2s. 6d. per share, or at the rate of 5 per cent. per annum, payable on the 16th proximo.

ELECTRIC LIGHTING ON SHIPS.—The "Aurania," a new steamer which is now approaching completion at the hands of Messrs. J. and G. Thomson, of Clydebank, and which has been built for the Cunard Steamship Company, will be lighted by electric light. Swan lamps will be used. They will be erected and fitted up by Messrs. Siemens Brothers.

ELECTRIC LIGHTING AT ROCHESTER (U.S.A.).—The Board of Aldermen of Rochester (U.S.A.) have contracted with the Brush Electric Light Company to maintain 48 arc lamps, at 45 cents. per lamp per night. It has been estimated by the board that the electric lamps will replace 325 gas lamps costing for light and maintenance 7,000 dollars per annum the estimated cost of the Brush lamps being 7,884 dollars per year.

ELECTRIC LIGHTING IN TRAINS.—The Pullman train to Brighton is now lit with 40 instead of 18 incandescent lamps, owing to the employment of the new Faure-Sellon-Volckmar accumulator supplied by the Electrical Power Storage Company. In the first instance 70 Faure accumulators (original pattern) were required for the 18 lamps, whereas now there are only 30 Faure-Sellon-Volckmar cells used for the 40 lights, their total weight being considerably less than half that of the cells originally employed.

EASTERN TELEGRAPH COMPANY.—This company announce the payment, on January 15th next, of a dividend of 3s. per share on the preference shares of the company, less income-tax, for the quarter ending on the 31st inst., and that an interim dividend of 2s. 6d. per share, with a bonus of 1s. per share, both free of income-tax, on the ordinary shares, in respect of profits for the quarter ended September 30, will be paid on the same date. The registers of transfers will be closed from January 8th to January 15th, 1883, both days inclusive.

ELECTRIC LIGHTING AT COVENT-GARDEN THEATRE.—The Metropolitan Brush Electric Light Company are engaged in setting up 24 Brush lamps in this theatre, in connection with the Christmas pantomime. Amongst other things, we believe that a Christmas tree will be shown, lighted by 50 incandescent lamps, the current for which will be supplied by a Schuckert dynamo machine. The arc lights will be fed from two 16-light Brush dynamos, driven by one of Fowler's compound semi-portable undertype engines. We shall hope to give further details of this work later on.

ELECTRIC LIGHTING IN BARCELONA.—Two cafés in Barcelona are lighted by means of Swan lamps, about 100 being used in each café. The current is generated in the works of the Sociedad Espagnola de Electricidad, situate in the Calle del Cid. The same company are erecting a central station at

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10, Ramble de Cavalites, in this town, where eventually 200 horse-power will be available in the shape of four 50 horse-power gas motors for driving electric light machinery. At the present moment several Gramme arc lamps, distributed about the town, are worked from this station.

How to Take Portraits of Burglars.—A correspondent of a contemporary suggests a new use for electricity in connection with burglars. He suggests that instead of utilising a current to ring an alarm, it should be adapted "to turn on momentarily the full glare of an electric light, and at the same instant expose a plate in a camera all ready to take an instantaneous picture. The burglar, of course, will take to flight, but will leave his photograph behind. The same blaze of light which has alarmed him will awaken the sleeping inmates, who can proceed at once to the camera and secure the negative."

Electric Lighting for Brighton. — The Brighton Town Council have adopted the recommendation of their Gas Committee to the effect that a provisional order should be applied for to enable the whole borough to set apart a permissive area for the supply of electricity for public or private purposes, and to constitute a part of the centre of the town, bounded on the north by North-street, east by East-street, south by Junction-road and King's-road, and west by West-street, an area for the compulsory supply of electricity. It is stated that this latter will entail an outlay of £100,000.

Electric Lighting at Oxford.—The Union Club at Oxford have entered into a contract with the Pilsen-Joel and General Electric Light Company to light up their premises by means of arc and incandescent lamps. Six Pilsen arc lamps will be used, and 100 incandescent lights. The dynamo machines will be driven by a gas engine, for which a special house is to be built. The Union Club is the possessor of a good library, and we believe that the decision to use electric lights in place of gas has been come to in the hope of saving their books from the destruction to which the use of gas renders them liable.

Continuous Lighting.—With reference to our note of the continuous lighting effected by the Edison Company on Holborn-viaduct during the recent foggy weather, we may mention that the Maxim-Weston Company lighted Southwark Bridge, Queen-street, Queen-street-place, and Queen Victoria-street, with 32 Weston arc lights continuously from the Saturday afternoon until the following Tuesday morning. The rooms of the South Eastern Brush Electric Light Company at 110, Cannon-street, E.C., were also lighted during the foggy weather by incandescent lamps, the current being supplied by the B. T. K. storage system.

Electric Light in Washington (U.S.A.).—The art exhibit of the Garfield Monument Fair (opened on the 26th of November), is held in the rotunda of the capitol. It is lighted by eight Weston arc lamps of 1,200 candle-power each. The effect is very brilliant and pleasing, the lamps being suspended from one of the galleries high up in the dome. There are besides six more lamps in other parts of the fair, all fed from a 14 light Weston dynamo, driven by an engine used for running the ventilating apparatus of the Senate Chamber. The plant is under the able management of Mr. N. W. Ellis, superintendent of the U.S. Electric Lighting Company of Washington.

Electric Lighting in London.—The Mile End Old Town Vestry have received a report from their Special Committee on the Electric Lighting Act. In this report the Vestry stigmatise the Act as "one of the most extraordinary character ever passed by Parliament, for, beyond a few general provisions, the whole matter of details is left in the hands of the Board of Trade." They also think the "knowledge of the science of lighting by electricity is small." Altogether, the Mile End Old Town Vestry's report is not favourable to electric lighting. And yet, if we are not mistaken, it was this same committee who were blown about in promiscuous fashion a few weeks back by an explosion of gas in the identical room where they were concocting this report.

Electric Bells for Prisons.—Since Lancaster Castle has been converted into a military prison great inconvenience has been experienced owing to the mechanical signals from each cell getting out of order. To avoid this, and in order to establish a reliable system of signals between the different officers of the prison, Mr. Sharples, electrician, of Preston, was instructed to devise and establish a system of electric signals. This has been done, and the work completed. It was, however, a somewhat difficult task, as may be gathered from the fact of the walls being in many places three yards thick. Over ninety of the cells have each been fitted with an electric bell push, so made and arranged that the prisoners cannot possibly damage it. The pushes communicate with an indicator in the chief warder's office, the different warders' offices being also connected with each other by electric bells.

Electric Lighting from Batteries.—Electric lighting on a large scale by means of batteries has recently been carried out in Paris. The Compoir d'Escompte is lighted by 50 arc lamps, Siemens and Gravier's, and 100 Swan lamps, the current being supplied by Jarriant and Grenet's bichromate batteries. The reason for employing this antiquated means of carrying out the lighting of the place is stated to be because no engine or gas motor is allowed on the premises for fear of fire. There are 60 batteries of 48 cells in use, each feeding an arc lamp or a group of from 8 to 10 incandescent lamps. The E.M.F. of each battery of 40 cells is about 82 volts, and the current 24 amperes, Messrs. Jarriant and Grenet estimate that each battery in full work develops energy equal to one and a half horse-power. The liquid in the batteries is renewed by special compressed air apparatus and numerous pipes.

Glasgow College of Science and Arts.—The prizes &c., gained by the students at this college were distributed a few days since by Mr. David Rowan. In the technological examinations of the City and Guilds of London Institute, Mr. James, Livingstone, telegraphist, General Post Office, obtained first-class honours in telegraphy, and Mr. George C. Douglas in mechanical engineering. Mr. William T. Calderwood (draughtsman, Messrs. Mirrlees and Watson) was first in the United Kingdom in pass grade of mechanical engineering, and was awarded £3 and the silver medal. Mr. James Law Crawford, electric-engineering student, was third in electric lighting, and obtained £2 and bronze medal; and Mr. D. M. Fletcher second-class honours in both practical and theoretical chemistry. The proceedings were closed by a few encouraging and congratulatory words from the principal of the college (Mr. A. Jamieson).

The Late Crystal Palace Exhibition.—Considerable impatience has been felt of late by exhibitors at the recent Electrical Exhibition in the Crystal Palace who had been awarded diplomas and medals, at the non-receipt of the same and the seeming apathy of the authorities in regard to the matter. Upon inqury a few days ago at the Crystal Palace, the secretary, Mr. W. Gardiner, stated that it had been the intention of the management to distribute the awards on the occasion of the opening of the present International Gas and Electric

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Exhibition on the 13th inst., but they had finally concluded to appoint a special evening therefor. He further stated that a diploma would be presented to each recipient of a medal. The prizes, which consist of diplomas of honour, gold, silver, and bronze medals (accompanied as stated by a diploma), are now ready, and the distribution, which will take place in the Palace, will be announced at an early date.

A WANT SUPPLIED.—In Mr. Preece's recent paper on Electrical Exhibitions, given in the *Journal* of the Society of Arts for the 15th inst., a new name will be found for a society which, not so long ago, was much perturbed as to what should be its appellation. The title given it by Mr. Preece (or the printer's devil), though peculiar, has, on the whole, an air of fitness about it, which no one will deny when he reads it in the light of certain events in the society's history. Mr. Preece is not unknown as a humorous and jocular lecturer of the first order, but his last joke is, so far as we know, his best, that is, if it really is his. Any one who will glance at the above mentioned issue of the *Journal* of the Society of Arts, p. 85, first column, immediately above the discussion on Mr. Preece's paper, will read "Society of Telegraph *Eccentricities* and Electricians," this being, we suppose, the latest effort to give the society a name which shall worthily represent it.

ELECTRIC LIGHTING IN THE COUNTRY.—The Town Councils of Liverpool and St. Helens have resolved to abandon their applications for provisional orders to supply the electric light in those boroughs.—The Sheffield Town Council have had their order prepared, but do not quite like having to "pay the piper." The Mayor has expressed his willingness to find the necessary money out of his own pocket. So far as we know, no decision has yet been arrived at on the matter.—The Jarrow Town Council have postponed the subject of electric lighting altogether for the present.—The Keighley Town Council will apply for a license, but not for an order.—The Bootle (near Liverpool) Town Council will apply for an order.—The Harrogate Improvement Commissioners have referred the matter to their Lighting Committee. Harrogate is supplied with gas by a private company.—The Knaresborough Improvement Commissioners will not apply for an order, and will oppose everybody else.

THE TELEPHONE IN LANCASHIRE.—The county justices of Lancashire have decided to connect the different wards, doctors' houses, &c., of the county asylum at Whittingham by telephone. This, the most modern asylum in the country, has about 2,000 inmates. Eight Gower-Bell telephones are to be used, the lines all converging to a central station, worked on the telephonic exchange system. The magistrates have instructed Mr. G. Sharples, electrician and telegraph engineer, of Preston, to carry out the work. It may be mentioned that Mr. Sharples some time since fitted up the county offices of Lancashire with telephones, electric signals, lightning conductors, and the large Record Room with twelve self-acting fire alarms, and also connected these offices, the county court offices, and the Sessions Court by three separate wires with the Preston Telephonic Exchange, of which he is the proprietor. This means of communication has been found a great convenience, as the Sessions Court is about one mile distant from the County Offices. Most of the other public buildings in Preston are also connected with this exchange, which has a large number of subscribers.

THE EDISON LIGHT IN MELBOURNE.—A recent issue of the *Melbourne Herald* contains an account of an exhibition of the Edison system by Major Flood Page, from which we extract the following. The exhibition was given in the Café Gunsler, Melbourne, where a dining room was lighted by Edison lamps. Our contemporary says:—"The tables, which were tastefully decorated, held bouquets, in each of which an Edison burner was placed, and the effect of the light shining through the petals was singularly beautiful. Two rows of lights, each of 10 burners, hung against the mirrors at the sides of the room, and two festoons of flowers, each holding 10 burners, crossed the room at either end of the tables. A cluster of five burners surrounded each of the ordinary chandeliers. Thus there were 50 lights in all, the result being a blaze of light which, had it been created by the combustion of gas, would have been absolutely unbearable. As it was, no one was affected by it, except in a very satisfactory fashion, for gentlemen who ordinarily find themselves compelled to use eye glasses, proved perfectly able to read an ordinary letter without them. Four gentlemen testified to this fact."

ELECTRIC LIGHT IN SYDNEY.—The *Sydney Morning Herald* office has been illuminated by the Edison electric light. In announcing the fact the *Herald* says:—"Wires at present are distributed over the composing frames and in the engine room, but the usurpation of the realm of gas has been so hasty that the shades were not properly adjusted, and hence the full value of the invention could not be apprehended. Enough, however, was seen to fill every one with admiring surprise, shadows being 'conspicuous by their absence.' . . . The difference in the temperature of the composing room, ordinarily very warm, during the time these lamps were burning was very marked. The order for the fittings was carried out by Mr. H. H. Kingsbury, representing Mr. Edison's interests in New South Wales. . . . Mr. Kingsbury had the whole of the paraphernalia fixed up, and, with the assistance of Mr. Patterson, engineer, the shafting adapted to the motor, in a very short space of time, without disturbing the routine of the establishment. The compositors, it may be mentioned, expressed their admiration of the new light, considering it superior to that to which they have hitherto been accustomed."

ELECTRIC LIGHT IN INDIA.—The opening of the Sirhind Canal at Rupar on the Sutlej by H.E. the Viceroy of India afforded to the Eastern Electric Light and Power Company an opportunity of displaying an installation consisting of both arc and incandescent lighting such as has never been seen in India. The camps of the Viceroy, the Lieutenant-Governor of the Punjaub, the civil and military, and the native chiefs were brilliantly illuminated by 48 Brush arc lamps of 2,000 candle-power each from the 22nd until the 26th November, and the reception and dining tents of the Viceroy were lighted by 36 Lane-Fox incandescent lamps of 20 candle-power, causing intense astonishment in the minds of the many thousand natives who crowded nightly round the engines and dynamos employed in the working, so much so that police had to be employed to keep them back. On the night of the 24th the current used for the lighting of the incandescent lamps was transmitted to lamps lighting the railway station for the departure of H.E. the Viceroy. As soon as his train left, the current was returned to his camp. The necessary power was supplied by three 16-light Brush dynamos, driven by portable engines.

THE BRUSH ACCUMULATOR.—Rumour has for some months been associating Mr. Brush's name with an accumulator, and we now have some definite news of the matter in the shape of the following telegram from the *Standard's* New York correspondent. The message was sent on Tuesday night, and runs as follows:—"The inventor of the arc light in the Brush exhibition claims to have solved the problem of the storage of electricity upon a commercial basis. His accumu-

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lator supported thirty Swan incandescent lights for six hours. It measures 10ft. long, and the ends are 18in. square. The accumulator was charged from the circuit for supplying the street lights while they continued to burn. Automatic mechanism stopped the current when the process of charging was complete. The accumulator had absorbed ten amperes of current when it was full. Its lighting efficiency, per horse-power of steam, was twenty-nine candles. This accumulator requires only one-third of the space taken by Faure's; while it gives the same results in regard to polarisation. Whether the current will overcome the durability of the plates is not decided; but it is believed that the solution which separates the plates is not destructive. I can only testify that the lamps burned, and that there is no apparent reason to question the inventor's claims. Mr. Edison announces his charges for supplying the electric light to houses at the rate of two dollars for one hour's light equal to 2,000 candles. This is equivalent to gas at two dollars per 1,000 cubic feet." Pending the receipt of further information from America, we advise our readers to take the major part of this message *cum grano salis*.

THE EDISON LIGHT AT BRUNN.—A correspondent writes:—"Yesterday morning (Sunday, December 17), at 12 o'clock, there arrived in Brünn, by special train, some 200 members of the Engineers' Club of Vienna. Their object was to inspect the Edison light system. They were met at the railway station by the Bürgermeister, G. Winterholler, the city engineers, Mr. Ross, who is the agent for the Soc. Electrique Edison in Austria, and Mr. Jehl, in charge of the Brünn lighting arrangements. After breakfasting in the station they proceeded to the theatre. The auditorium and stage lights only were in operation. Everything was shown to them, the regulator, its operation, showing how each individual line could be operated, one, two, three, or more at the same time, or all of them together. The application of Edison's safety cut-out was also shown and explained, the main switch and cut-out which is in the cellar of the building and controls the stage and the other part of the house, the rooms, halls, &c. From the theatre they went to the machine room, and saw the dynamo machines, steam engine, &c., in operation. As each engineer left the room he was presented with a drawing showing the arrangement of the machines and engines. The speculations as to how the electricity was developed were amusing, some ascribing it to the friction of the brushes on the commutator, and so on. What puzzled some of them most, however, was the absorption of power. They could not conceive a bobbin revolving, and taking 8, 10, 20 horse-power as the case might be. After viewing the machines they went back to the theatre and witnessed the afternoon performance, which they much appreciated. In the evening they were entertained in the 'Turn Halle,' returning to Vienna about 9 p.m."

PROFESSOR HENRY DRAPER.—America has suffered a great loss in the death of the distinguished scientist, Professor Henry Draper, which occurred recently at his residence in New York. His death, at the age of 45, was altogether unexpected. A few evenings previous to his demise he entertained the members of the National Academy of Sciences, and immediately afterwards complained of pains in the chest. These developed into pleurisy, and made such rapid progress that death resulted a few days after. Professor Draper, who was the son of the late Professor John Draper, was born in the State of Virginia, and graduated from the Medical Department of the University of the city of New York in 1858, after which he spent some time in Europe visiting and studying places and instruments connected with scientific investigation. He held a number of positions of high public distinction, but resigned them early this year, as they interfered with his original researches. He made at Hastings, on the Hudson, the largest telescope in the United States—an equatorial telescope of 28in. aperture, whose construction has been justly described by President Barnard as "probably the most difficult and costly experiment in celestial chemistry ever made." His work on the grinding and polishing reflecting mirrors and methods of testing them is a standard volume to this day. His laboratory connected with his private residence in New York was one of the best equipped in the world, being fitted with the most refined and costly apparatus, much of which was his own invention and construction. His astronomical successes were innumerable. He was connected with the Commission of 1874 to observe the transit of Venus, and received a special gold medal for his labours, struck by the United States Mint by order of the Government. His wife, a daughter of Cortlandt Palmer, whom he married in 1867, was his most competent and enthusiastic assistant in his scientific work.

INFLUENCE OF TEMPERATURE ON MAGNETISATION.—M. Bersen has studied the influence of temperature on the magnetisation of iron, steel, nickel, and cobalt. He places the bar to be experimented on in a constant magnetic field, at different temperatures, and compares its magnetic moments. To make this comparison he adopts the method of Gauss. His apparatus consists of a Bunsen battery of from six to ten cells, the current from which, after having passed through a commutator, traverses a retort carbon rheostat, then the coil which serves to produce the magnetic field. A galvanometer placed in a shunt enables this current to be kept constant. In this magnetising coil is placed the bar, which causes a small declination needle, suspended by a thread to the interior of a copper cage, to deviate. The deviations are read by means of a mirror and scale. The magnetising coil, which must be capable of withstanding high temperatures, is composed of a wire wound without permitting the coils to touch, on a glass core, and covered with plaster. The whole is placed in a copper stove and heated by a gas lamp. The temperature, which is maintained constant as long as possible, is measured by a thermometer thrust into the stove. Some of the results obtained are as follow:—As regards iron, magnetisation is nearly independent of temperature. The total and temporary magnetisations increase up to 260deg., then they decrease, whilst the permanent magnetisation diminishes very slightly. With steel, the total magnetisation increases at first, attains a maximum at 260deg., and then decreases; the permanent magnetisation attains its maximum towards 240deg. Variations of temperature during the experiment exercise an influence on the magnetisation, which increases under these conditions. If the temperature of a bar magnetised when cold be raised, its magnetisation diminishes; the same occurs if a bar, which has been magnetised when hot, is cooled. If, now, we temper this latter it retains a greater magnetic moment than if it had been worked at a low temperature. With nickel, the total magnetisation slowly increases up to 240 degrees, and after reaching 280 degrees decreases very rapidly, becoming *nil* at about 330 degrees. Nickel magnetised at a low temperature and heated to 330 degrees loses all magnetisation; if, on the other hand, it has been magnetised at 280 degrees, and subsequently slowly cooled, its magnetic moment begins at first to increase, then decreases at about the ordinary temperature, but finally remains greater than at the temperature of magnetisation. Cobalt behaves like steel.—*La évue Industrielle.*

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ELEMENTARY ELECTRICITY.

IV.

As before stated, the object of an electroscope, or electrometer, is the detection of difference of potential between the bodies to which its electrodes are attached. The amount of charge upon the bodies is not registered directly by the instrument, but in some cases the amount of charge on a conductor can be determined by an electrometer, though this implies a knowledge of the *capacity* both of the conductor and of the electrometer itself. This will be better understood when electric capacity has been considered.

The action of the gold leaf electroscope may be illustrated by the following experiments. In the instrument employed a wire gauze cylinder should be placed surrounding the leaves, and connected with a wire which passes through the stand of the instrument. The diameter of the cylinder should be such that if the leaves diverge very widely they may touch the gauze, and thus become discharged before they incur the risk of being torn. Let the electroscope be placed on an *insulating stand*.

Exp. I.—Connect the wire gauze to the earth by fastening the wire attached to the gauze to a gas-pipe. Now bring a small brass ball, which has received a positive charge from an electric machine, near to the plate which forms one of the electrodes of the instrument. The leaves will diverge, but if the ball be removed they will collapse again. On bringing the ball nearer they will diverge still more, and if the ball be made to *touch* the plate and be then removed the leaves will remain diverging. The leaves are now charged with positive electricity. If a negatively-electrified body be brought near the plate of the electroscope the leaves will tend to collapse, but if a positively-electrified body approach the plate the leaves will diverge still more. We are thus furnished with a means of determining whether it is positive or negative electrification which is causing the leaves to diverge.

Exp. II.—Detach the wire from the gas pipe and connect it with the plate of the instrument, thus making a metallic communication between the gold leaves and the wire gauze, but leaving no communication between any part of the instrument and the earth. Connect the plate with the prime conductor of an electric machine, and charge the instrument as strongly as possible. *No divergence* of the gold leaves will take place. (This is, of course, consistent with the statement that there is no electrification upon a conductor which is placed inside a closed hollow conductor, and is in electric communication with it.)

Exp. III.—The instrument being charged as in Experiment II., by means of a glass rod, or pair of pincers with insulating handles, remove the connection between the plate of the electroscope and the prime conductor of the electric machine; then break the connection between the gauze cylinder and the plate, and connect the gauze cylinder with the earth. So long as the wire connected with the cylinder remains insulated no divergence of the leaves will take place (if there be no leakage from the wire) but on making the earth connection the leaves will diverge violently and discharge themselves by touching the gauze cylinder.

Exp. IV.—Repeat the charging of the apparatus as in Experiment II. Then, having disconnected the electric machine, break the connection between the gauze cylinder and the plate, and, keeping the *cylinder* insulated, connect the plate to the earth. The leaves will again diverge and touch the cylinder. In this experiment the leaves diverge, although they are in connection with the earth, the gauze cylinder being insulated.

If in Experiments III. and IV. the instrument be only slightly charged, so that the leaves do not discharge into the gauze cylinder, but remain diverging when the cylinder or plate is put in connection with the earth, we may determine, as in Experiment I., whether the leaves are positively or negatively electrified. In the case of Experiment III. we shall find that the leaves are positively electrified, and in the case of Experiment IV. that they are negatively electrified, but in the latter case we must remove the earth connection from the plate before bringing up the electrified body which is to determine with what kind of electrification the leaves are diverging.

The results of the preceding experiments are easily explained if we remember that an electroscope indicates simply the difference of potential between the conductors connected with its electrodes, or, which is the same thing, the difference of potential between the gold leaves and the gauze cylinder. When these are connected, as in Experiment II., they are at the same potential, and no matter how high or how low that may be, no divergence of the leaves will take place. When, as in Experiment III., the cylinder is disconnected from the leaves, and put to earth, the potential of the cylinder is reduced to zero, while that of the leaves and plate remain high (though not so high as before the cylinder was put to earth), and the difference of potential of the leaves and cylinder is now made manifest by the divergence of the former. When, as in Experiment IV., the gold leaves are put to earth, the cylinder remaining insulated, the potential of the gold leaves is reduced to zero, while that of the cylinder remains high. The leaves then diverge so as to indicate the difference of potential between themselves and the surrounding wire gauze, and the leaves being now at a lower potential than the cylinder, their electrification is *negative*. These experiments, therefore, teach that the electroscope indicates difference of potential between the leaves and the wire gauze, and that both may be raised to the *same* potential, however high, without any indication occurring.

When the electroscope is used to measure the excess of the potential of a conductor above that of the earth, the wire gauze cylinder should always be connected with the earth, if possible by means of a gas or water pipe.

Coulomb's *proof plane* is a small piece of thin metal, mounted on an insulating handle, and shaped so as to fit accurately the portion of the surface of the body to which it is intended to be applied. It is, therefore, very seldom that it is really *plane*. If such a proof plane be applied to the surface of an electrified body it becomes virtually a part of that surface, and electrified in the same way as the surface it covers was before the application of the proof plane. If the proof plane be then carefully removed from the surface so as to break contact at every point at once, it will carry away just the amount of electrification which existed originally on the part of the surface which it covered. As no electricity can remain within a closed, or practically closed, conductor, it follows that no electricity can exist on the portion of the surface beneath the proof plane or on the lower surface of the proof plane itself, either while the "plane" is resting on the body, or when it has been removed only to a small distance from the surface. Hence the "plane" will carry away only as much electricity as originally occupied the portion of the surface covered by it, though this will spread over both sides of the proof plane when it has been removed far enough from the influence of the electrified body. If we are furnished with proof planes, and an electroscope, the gold leaves of which are diverging with a small charge of positive electricity, we can test the nature, and can roughly test the amounts of electrification on any portion of a surface to which the proof plane is applied.

On Electric Accumulators.

Exp.—Take two plane metal discs, A and B, supported on insulating stands, and let A be charged positively by an electric machine, and then insulated. Now bring B up so as to be very near to A, and parallel to it, and let the electrification of each side of B be tested with the proof plane. It will be found that the side of B which is nearest to A is negatively electrified, while the opposite side is electrified positively to the same extent. This electrification of B is an example of electrostatic induction. Now place B in communication with the gold leaves of an electroscope by means of a wire, the gauze cylinder being "put to earth." The leaves will diverge, and if the connection between the leaves and the plate B be now broken, and the electrification of the leaves be tested, it will be found that they are positively charged, indicating that the plate B is at a potential above that of the earth. If the wire connecting the gold leaves of the electroscope with the plate B be made

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to touch either side of B the result will be precisely the same—the electrification of the gold leaves, and, therefore, the indication of the electroscope depending only on the *potential* of B and not on the electrification of the particular point to which the wire is attached. Thus, the proof plane serves to detect the *electrification of the surface* to which it is applied; the electroscope deals with the *potential of the conductor*. If A be connected with the gold leaves they will diverge somewhat more than when B is so connected.

Now, let the plate B be connected to the earth for a short time, and then tested as before. The side nearest A will now be found to be negatively electrified, and more strongly so than before, but the side remote from A will be *unelectrified*. On connecting the plate B itself with the electroscope no divergence will take place, indicating that B is at the same potential (zero) as the earth, which must clearly be the case when B is connected with the earth. If the plate A be now examined by means of the proof plane it will be found to be positively and very strongly charged on the side near to B, but to possess only a very feeble positive charge on the other side. On connecting the plate A with the gold leaves it will be found that it is still at a positive potential, but at a very much lower potential than it possessed before B was put to earth.

If, before B was brought near to it, the plate A was charged as strongly as was possible with the electric machine employed, then, when B is very near to A and in communication with the earth, the same electric machine will be found capable of increasing the charge of A till it is many times as great as it was before B was introduced. This is due to the fact, which we learned just now, that the potential of A is very much reduced by the negative charge induced upon B, and in order to raise A again to the potential of the prime conductor of the machine, notwithstanding the negative charge on B, which increases in the same ratio as the charge on A, it is necessary to increase the charge on A in a corresponding ratio. Thus, if the presence of B reduces A to a potential only one-tenth of that which it previously possessed, then in order to raise A again to its original potential, while B is kept connected with the earth, its charge must be increased ten-fold.

Two plates, such as we have described, one of which is insulated and the other connected to the earth, form an electric *condenser* or *accumulator*. The amount of electricity necessary to raise the plate A to the potential of the prime conductor of the electric machine will be greater the nearer the condensing plate B is made to approach to A. The only limit to the approach of B is determined by the passage of a spark between the two plates when they are brought very near to each other.

In the experiments just described the plates of the condenser should be very large in comparison with the parts of the electroscope. A quadrant electrometer may be substituted for the electroscope, and this will have the advantage of showing at once whether the potential of the body connected with it is positive or negative, as well as measuring the numerical value of the potential, but in this case a very feeble source of electrification must be employed.

Def.—The *capacity* of a conductor is the number of units of electricity required to charge it to unit potential.

The capacity of a conductor depends partly on its own size and shape, partly on the nature of the dielectric in which it is placed, and partly on its relations to other conductors.

When a body is removed from the action of all other bodies, it is said to be *isolated*.

The capacity of an isolated body depends only on its own size and shape, and the nature of the dielectric surrounding it.

In the case of a condenser, the capacity of the receiving plate A may be enormously increased by the proximity of the condensing plate B. The capacity of the receiving plate, when the condensing plate is put to earth, is called *the capacity of the condenser*.

If a plate of glass, sulphur, shellac, ebonite, paraffin, or any other solid or liquid dielectric be introduced between the plates of a condenser without changing the distance between the plates, the capacity will be found to be greatly increased.

Def.—The ratio of the capacity of a condenser having any substance for its dielectric to that of an otherwise equal condenser which has air for its dielectric is called the *specific inductive capacity* of the substance.

The differences between the specific inductive capacities of dielectrics are due to the fact, previously mentioned, that the repulsion (or attraction) between two given charges of electricity separated by a given distance depends on the nature of the dielectrics being less in solid or liquid dielectrics than in air. If K denote the specific inductive capacity of a dielectric, then the quantity of electricity which acting on an equal quantity at unit distance repels it with unit force, will be proportional to $\sqrt{K}$, and this will be the proper unit of electricity for experiments conducted in this particular medium. Thus the unit of electricity corresponding to a medium whose specific inductive capacity is K will be $\sqrt{K}$ times the ordinary, or air, unit. The unit difference of potential is the difference between the potentials of two points, in virtue of which the unit of work is done on the unit of electricity in passing from one point to the other. If the unit of electricity be increased the unit difference of potential will be decreased in the same proportion, so that the unit difference of potential corresponding to a medium whose specific inductive capacity is K will be $\frac{1}{\sqrt{K}}$ times the ordinary, or air, unit. The capacity of a condenser measured in terms of the units properly belonging to its own dielectric depends only on the geometrical relations of the conductor; but, to express this capacity in ordinary, or air, units, we must multiply by the factor K, since the unit of electricity referred to is $\sqrt{K}$ the ordinary unit, while the unit difference of potential employed is only $\frac{1}{\sqrt{K}}$ of the ordinary unit.

The Leyden jar is an example of the electric accumulator. It was first discovered accidentally by Cuneus, who endeavoured to give a charge of electricity to a quantity of water contained in a phial by sending sparks from an electric machine into the water by means of a nail which passed through the cork of the phial and dipped into the water within. The phial was held in one hand during the charging, and the nail was then touched with the other hand, when a severe shock was felt. In this case the water acted as the receiving plate, and the hand which held the phial as the condensing plate, the glass serving as the dielectric. The hand being in communication with the earth, all the conditions necessary for the operation of the condenser were fulfilled, and a very strong charge was, consequently, accumulated, glass having the advantage over air not only of a very great specific inductive capacity but also of a great electric *strength* or ability to resist a disruptive discharge taking place through its substance, so that the plates of a condenser when separated by a plate of glass may be much nearer to one another, for the same difference of potential, than when air is the dielectric.

The Leyden jar, as generally constructed, consists of a glass bottle, lined inside and outside with tin foil to about two-thirds of its height. It is generally closed by a wooden lid, through which passes a brass rod, terminating above in a knob and communicating below with the inner coating of the jar by means of a brass chain or otherwise. To charge the jar the outer coating or armature is connected with the earth, so as to form the condensing plate, while the inner coating is put in communication with the source of electricity. If, after charging the jar, a metal rod be connected with the outer coating, and one end of it made to approach the knob, which is in communication with the inner coating, a little before contact occurs a violent discharge will take place, producing a spark across the interval between the metal bar and the knob, and leaving the jar almost discharged.

Condensers are now made of very great capacity for use in submarine telegraphy. These are generally constructed of plates of tin-foil separated from one another by sheets of paper which have been saturated with melted paraffin. The alternate tin plates are connected together so that the first, third, &c., plates are connected with one electrode of the con-

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denser, and the second, fourth, &c., plates with the other electrode. Standard condensers are sometimes made with plates of mica instead of paraffin paper for the dielectric.

THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 105.)

Before leaving this subject, it will be well to illustrate a few cases where, having a certain battery and the means of adding on another similar battery, we may add the second battery so as to obtain the greatest increase of the current. In the first place, if the external resistance is equal to the resistance of the battery, then, if we add the second battery on in series so as to double the resistance of the battery, and double also its electromotive force, we obtain the same current as when, by placing the second battery in parallel circuit with the first, we halve the resistance of the batteries, whilst maintaining the electromotive force constant. This is seen in Fig. 32, where B C is the resistance of a battery equal to A B, the external resistance, and C E, the E.M.F. Then A E is the potential line. If now we add on a similar battery in series, then the resistance of combined batteries becomes B G (double B C). The E.M.F. becomes G H (double C E), and the potential line becomes A H, which shows an increase of current. If, instead of placing the second battery in series with the first, we place it in

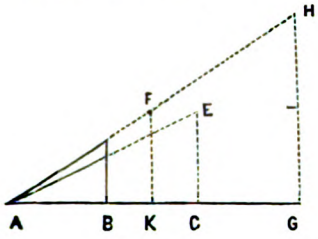

FIG. 32.

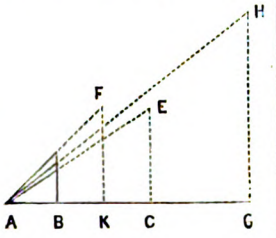

FIG. 33.

parallel circuit, then the resistance of combined batteries becomes half what the single battery was, and the combined resistance is B K, and the E.M.F. remaining the same as with the single battery, we get F K for the E.M.F. Now since A B = C B, and B C is bisected at K, A K is equal to half A G, and as also F K is half G H, we have A K : F K :: A G : H G, and as K F is parallel to G H, F must lie in a straight line between A and H; or, in fact, we have the same current whether we place the batteries in series or parallel. If the external resistance is less than battery, then placing the second battery parallel we obtain greater increase than if we had placed it in series with the other, as seen in Fig. 33, where the same lettering applies, the point F now falling outside the line A H, showing that the potential line A F, which is that obtained with the batteries in parallel circuit, is steeper than A H, which is that obtained with the batteries in series. If the external resistance is greater than the battery, then in the same way it will be seen by Fig. 34 that it is best to put the second battery in series, for here the potential line A H falls outside the point F, showing that there is a greater increase of current by placing the two batteries in series than by placing them parallel.

We will now see how the line of potential in a circuit is altered by branch conductors.

It has been proved by mathematicians that the joint resistance of two conductors in parallel circuit is a fourth proportional to their sum and the two resistances. Thus, if we have two resistances a and b, then if they are joined in a parallel circuit we have $a + b : a :: b : x$ (the joint resistance), or $\frac{a \times b}{a + b}$ = joint resistance. This can be projected geometrically thus:—Suppose A B (Fig. 35) a resistance, and A D another, added in parallel circuit, attached to the pole of a battery of a resistance A L and E.M.F. = L E. Then, if A D did not exist, the potential line would be E B, giving a potential at the battery pole A of A P. Now, suppose A D added. Mark off D', making D' A = A D. Erect a perpendicular at D', and cut off D' D'' equal D' A. Erect a perpendicular A C at A, and join D'' B, cutting A C at F. Then A F is the fourth proportional to A B + A D, A B, and A D. For we have B D' (= A B + A D.) : D' D'' :: A B : A F. If now we make A K equal to A F, then the total resistance of the circuit is L K, and joining E K, cutting A P at O, we get A O as the

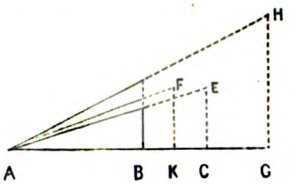

FIG. 34.

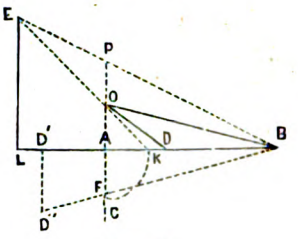

FIG. 35.

potential at the battery pole. Joining now O D, we get the line of potential in A D, giving for current in A D, $\frac{A\ O}{A\ D}$ and joining O B we get the line of potential in A B and

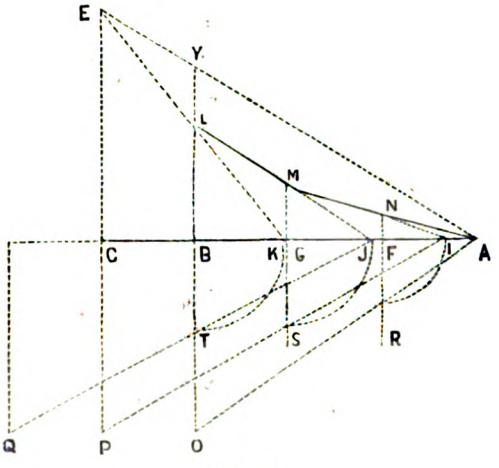

FIG. 36.

$\frac{A\ O}{A\ B}$ as current in A B, the total current in the circuit being $\frac{L\ E}{L\ K}$.

By the same process we may project the line of potential

FIG. 37.

in a circuit when there are branches at several places, as, for instance, in a line having faults at certain distances. Suppose thus in Fig. 36 C B to be battery resistance, and B A the line three miles long, having at the battery pole, B, and at the first and second mile a leakage fault having a resistance equal to two miles of line. Then first we must find the joint resistance of the last fault towards the earth end and the last mile. This, it will be seen, is done by erecting a perpendicular at F, then at B (two miles from F) and cutting off B O equal to two miles. Joining O A, we cut the perpendicular erected at F, at R, and making F I = F R, we get C I as the total resistance of the circuit if there were no other faults.

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Proceeding in the same way with the fault at G, we get C J as the total resistance if the fault at B did not exist. Now, proceeding in the same way at B, we get C K as the final total resistance of the circuit. Joining E K gives B L as the potential at the battery pole. Joining L J gives G M as the potential at G, and joining M I gives F N as the potential at F. The line of potential from the battery pole L to the end at earth at A is thus given by the lines L M N A, and the current issuing from the battery is $\frac{C E}{C K}$, and the current issuing at the end to earth is $\frac{F N}{F A}$. Had there been no faults in the line the potential at the battery pole would have been B Y, and the current throughout the circuit would have been $\frac{C E}{C A}$.

It is easy to see that in a line which leaks uniformly throughout, as, for instance, in a subterranean line, insulated with some uniformly bad material, the line of potential will become a curve, as shown in Fig. 37.

THE INDUCTIVE AND CONDUCTIVE CIRCUITS.

BY JOHN T. SPRAGUE.

It is generally considered that static electricity and dynamic electricity require distinct treatment. The result is that few people acquire clear conceptions as to both branches, and the formulæ and laws of the one are apt to prove an encumbrance when studying the other. The real distinction between the two is, however, nearly unknown, and not pointed out in any of the books. That distinction is that there is no such thing as a *quantity of static electricity*. It is quite true that we have two definitions of such a quantity, but those definitions themselves disprove its existence when studied.

The coulomb appears to be a unit of quantity, and it really is so as to dynamic electricity. The microfarad appears to be a receiver capable of comfortably holding a quantity of electricity like a pint bottle would a quantity of air, and that in ratio of the pressures put upon it.

The coulomb is, however, a quantity of electric *action*, not necessarily a *quantity of electricity*, even of dynamic electricity, because its truth and utility are equal, whether we consider electricity as an entity, a fluid, or as merely a function of molecular or etherial motions and changes. Its value is fully definable as a material, actual quantity, because it releases a definite weight of hydrogen or other substance. This gives it a quantitative material value. A micro coulomb is one-millionth, and we can bottle this up in a microfarad and take it out again. Is that quite sure? Is it *electricity* we have put into our bottle?

What is the microfarad? The only essential part of it is a *dielectric*. The coatings only serve as the neck of the bottle, a pathway—electrodes. What, then, is a dielectric? It is a substance in which a certain state of *stress* can be produced, developing a *field of force*; that field of force is of such a nature that it is produced by what we call electricity, and will give us back the energy stored up in the stress as electricity again. Then it may be energy stored under particular conditions, not electricity, just as in secondary batteries we can store energy in the form of chemical affinity ready to reproduce electricity.

The other unit of electro-static quantity is that quantity which, placed at unit distance, repels an equal similar quantity with unit force. But the very definition tells us that this is a quantity of a force; it is simply the reaction of the "field of force" existing between the two electrodes.

Returning to our bottle of air, we find in it two things, a "quantity," the air itself—a "pressure" exerted by the air. Are not these the two things we find in electricity—a something definable as a "quantity" in dynamic electricity, which something exerts a "static pressure," related to the energy charged upon the "field of force" generated in that air? In this case, however, the air itself plays the double part; in electricity, whether there be a quantity of it having existence or not, it needs another substance, the dielectric, to store the energy, which, however, it may be said, corresponds to the material of the containing bottle.

The distinction drawn does not depend on the analogy, for this always fails at some point. The point itself is that the phenomena of static electricity, are related, not to quantities of electricity, but to energy operating in a field of force; whenever "quantity" comes into play, as in discharge, we are no longer dealing with static, but with dynamic electricity. To make this clear it is necessary to consider some of the actions which occur.

According to the mathematical theory of electricity, current, &c., discharge, &c., are due simply to *difference of potential*, the actual position of the two points on what we may call the "scale of potential" having no influence. This is, of course, analogous to currents generated in a column of water, which may be regarded as a "scale of potential;" such a current issues from any point in the column as is due to the head of water above that point, however high up in the scale it may be itself.

The same effect will arise between two points in an electric circuit, whether those points are at + 15 and + 5 potential as regards zero, and though both of them have free + charges, as would occur between two points at + 5 and — 5, with equal free + and — charges. The facts are, of course, true, and and for some of the purposes of calculation, the theory has its advantages. But the theory is not true as a fact of nature. The water analogy itself disproves it; the column of water below the point at which current passes is inert, *it is not in the circuit*. The same is the case with the electric circuit. It is true that we can have two Leyden jars charged to such differences, with their external coatings connected together, as will represent the scale of potential, the external coatings being the + and —. But then we may connect the junction of the external coatings to the theoretical zero of potential, the earth, and no current will pass. The analogy to the opening in the column of water fails. But why? Simply because we have two distinct inductive circuits. Each jar is complete in itself just as a battery cell is. We can discharge the jars singly just as we can take current singly from two cells joined in series, or we can discharge them in series with the effect due to the sum of the potentials, just as we can use the cells.

In fact each jar, *i.e.*, each inductive circuit, has its own scale of potential, of which the — is at zero. The theoretical, or earth zero, is a mere artificial invention for purposes of calculation; it is precisely the same with the column of water. The total height of the column has no actual relation to the result, and the zero is not the earth level (in fact, if anywhere it would be at the earth's centre); but for each current the real zero is the point at which it issues.

To meet the fact that no discharge will occur at the common junction to "earth," although that junction is at + potential, the other artificial doctrine of *bound* electricity is invented. The free charge on the inner coatings dissimulates an equal quantity on the corresponding outer coating; but what is the use of this complication when the case is absolutely analogous to that of the two galvanic cells? As long as the cells are open, they are under identical conditions with the charged jars; in both there is a break of connection—an inductive circuit between the poles which the force cannot break down. Under these circumstances we can insulate the jars, either connected or separate, and we can give them a *free charge*. But what is this but adding a third inductive circuit? We can even charge the external coatings + or —, but in so doing we simply make the outside surfaces the one coating to the air of the room to which the other coating is the surrounding surface. We can even put opposite free charges on the two jars in the same manner, and we can make these charges either the same or the opposite of the charges which their inner surfaces bear as regards the inner coatings.

All this becomes perfectly clear when we examine each separate inductive circuit as we should the circuits of currents, which every one knows may be absolutely distinct though they all unite at a common point, or even traverse some part of a common conductor.

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We may now contrast and compare the two orders of electric circuits.

The *conductive circuit* consists of matter which allows electrical action to take place in the form of current, or we may say it permits electricity to pass. It does so in quantities related to the electromotive force, to the conducting capacity of the material substance, and in producing current the electricity expends energy.

The *inductive circuit* consists of matter which does not transmit electricity, but admits of the formation of a field of force manifested as *charge* at its opposite sides. Such "charge" is proportional to the potential, to the inductive capacity of the material called the dielectric, and in producing charge the electricity expends energy.

It will be better now to present the relations in parallel columns:—

Static.	ELECTRICITY.	*Dynamic.*
Energy *potential*; stored in a field of force, as stress in a dielectric	means	Energy *kinetic*; acting in a conducting path along molecular chains.
Inductive.	CAPACITY.	*Conductive.*
Area of dielectric. Spec. ind. capacity of dielectric.	varies as	area of conductor. specific conductivity of material.
Thickness.	inversely as	length.
Inductive.	RESISTANCE.	*Conductive.*
Reciprocal of conductive capacity.	is the	reciprocal of conducting capacity.
CHARGE.		CURRENT.
Potential in Volts.	is as	electromotive force in volts.
Resistance.	inversely as	resistance.
Inversely as the several resistances.	divides among several circuits	inversely as the several resistances.
Lines of forces under stress.	is related to and dependent on	lines of equivalent molecules forming chains.
	ENERGY, OR WORK.	
Square of charge in unit or equal resistance.	is as	square of current in unit or equal resistance.

FORMULÆ.

Charge $\frac{E}{R} = Q$	Current $\frac{E}{R} = C$
Potential $Q \times R = E$	Electromotive force $C \times R = E$
Resistance $\frac{E}{C} = R$	Resistance $\frac{E}{C} = R$.

As to the capacity, the specific inductive capacity is measured in its own terms, by the charge received under unit potential by a unit dimension, as, for instance, a square foot of 1 mil. in thickness of the material. Specific conducting power is usually and most conveniently measured as a resistance of a unit dimension, such as a wire 1 foot long and 1 circular mil. in area. Resistance and capacity being reciprocals of each other it is indifferent under which term it is measured.

The influence of thickness of dielectric is taken here under its simplest form, as a plate whose area vastly exceeds its thickness, which is practically in the form of concentric spheres of very large radius. This is correct, not only because it is simple, but because the comparison is really to be made between the areas which would transmit a unit of current or take up the same unit as charge, and this latter area is many million fold in the dielectric what it is in the conductor.

A TELEPHONE NUISANCE.—"Inspector" writes from Columbus, Ohio: "I have made a discovery which may prove of great value to telephone exchanges throughout the country. Though the experiment will require a considerable outlay, it may prove a saving of time to inspectors and of patience to subscribers which will compensate for the expenditure (for I have also discovered that a subscriber loses his temper in case of trouble with his telephone). One day last week a line was reported open, and on investigation the magneto-bell box was found to be literally packed with cockroaches. The switch had crushed several of them, thus causing the trouble. My suggestion is that the construction men and inspectors be provided with boxes of insect powder and instructions to give every instrument a thorough dosing when it is put up, and every time it is inspected."—*Operator.*

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS' ANNUAL MEETING.

The annual meeting of this society was held at the Institute of Civil Engineers on 14th inst, Lieut.-Colonel C. E. WEBBER, R.E., C.B., president, in the chair. After the transaction of some formal business, the report of the council was read by the secretary. The number of new members and associates had increased during the year by about one hundred; and the funds of the society were in a satisfactory condition, it being stated, for one thing, that life compositions alone, amounting to £741, had now been invested in Government or other securities. Some steps had been taken to place the society on a footing so that it could be registered under the Joint Stock Companies' Act, and it was hoped that correspondence on the subject would be so far advanced very shortly as to enable a general meeting to be called to authorise what was being proposed. The report also recapitulated the various papers read before the society during the year, and the leading events in which the members had taken part. The exhibitions at Paris, at the Crystal Palace, and at Munich, and the visit of the society to Chatham, at the invitation of the Royal Engineers, were specially mentioned; as also some brief reference to the forthcoming exhibitions at the Crystal Palace and the Aquarium. The recent conference at Paris for the determination of electrical units would not complete its report till October next year, to which date its meeting had been adjourned. There was reason to believe that the rules drawn up by the council of the society in conjunction with representatives of the fire insurance societies for the laying down and maintenance of electric lighting wires with special regard to the risks of fire had proved acceptable, as they were being very generally adopted. Those rules were now printed in a separate form as well as in the society's *Journal*. The fund provided by Mr. Fabie, and by the surplus accruing from the Paris Exhibition guarantee, had been invested so as to enable the society to offer prizes for original papers each year; and this it was hoped would prove a stimulus to young members to put their ideas or inventions into shape on paper, and bring them before the society.

The librarian's third annual report was also read. During the year additions to the library to the extent of 245 volumes had been made, chiefly by presentation. A considerable increase had taken place in the number of visitors, showing that the advantages of a library of this kind were meeting with growing appreciation. Although theirs was an electrical library, it was desirable that works—standard works, at all events—on physical science generally should be added to it; and the librarian hoped that the liberality already shown in respect to purely electrical works might extend itself also to works of the kind just mentioned.

The report being adopted, a vote of thanks was proposed to the Institute of Civil Engineers by Mr. E. GRAVES, the hon. treasurer, who in felicitous and graceful terms pointed out how deeply the society were indebted to the liberality of the Council of the Civil Engineers, in whose beautiful and commodious theatre it was their privilege to meet.

This vote was duly seconded and carried by acclamation, as was also a similar vote of thanks, proposed by Mr. Latimer Clark, to the foreign secretaries.

Mr. THOS. J. LARKIN'S paper on "The Application and Extension of Telephonic Communication in Japan" was then read. The chief novelty of Mr. Larkin's paper was in the fact of the Morse instrument in Japan having been largely superseded by the telephone. This at all events appeared to be the case on certain railways, and for the local purposes of police in the chief cities. The telephone had some obvious advantages over ordinary signalling instruments in that it required no skilled manipulators, and was immensely superior to mere bell signals on railway systems in the fulness and completeness of its means of communication between the signalmen. The circumstances of the capital of the country rendered communication of this kind most desirable. The houses being of wood, and extending over a wide area, the outbreak of fire was a thing to be notified as quickly as possible, as also the action of armed robbers, and emeutes, which were of by no means infrequent occurrence, and called for speedy concentration of troops.

In the course of the evening the result of the balloting for the officers of the society for the forthcoming year was announced by the president, the gentlemen nominated by the council all being elected. Mr. Willoughby-Smith was the new president; Sir Charles Bright one of the vice-presidents; Professor Ayrton, Mr. T. Russell Crampton, and Dr. J. H. Hopkinson, the three new members of the council; and Lieutenant A. H. Bagnold, R.E., Mr. Shelford Bidwell, and Mr. J. C. Lamb, the three new associate members of the council.

The next meeting of the society is fixed for January 18, 1883.

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THE ELECTRIC LIGHT AT THE NEW LAW COURTS.

Instead of illustrating the switchboard used at Berechurch Hall, as we had originally intended, we give herewith a description and illustrations of the larger ones that have been employed by Messrs. R. E. Crompton and Co. at the Law Courts.

The current from the six dynamos, of which, however, only three were placed on the opening day, is collected in the switchboard shown in Fig. 1, and is led by main cables, shown by thick black lines on the right of the board overhead, and across an at present unoccupied space into the

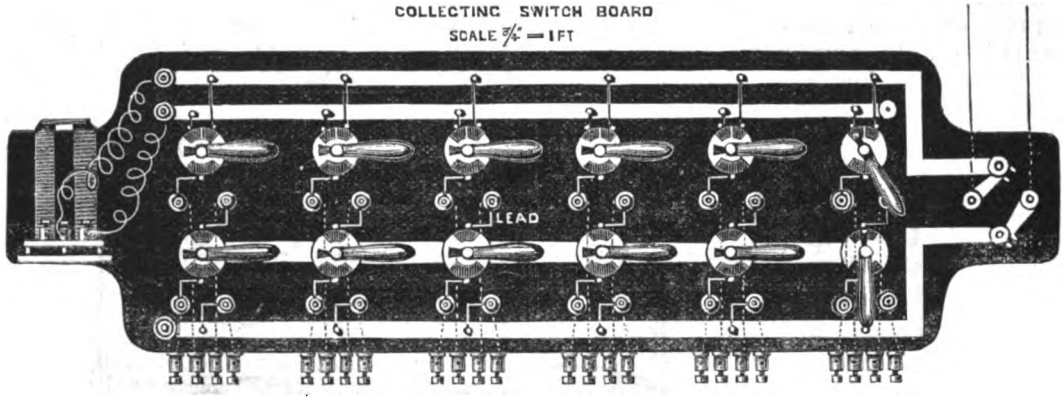

Fig. 1.

main building of the Law Courts, where they are brought across the crypt into a little room which contains the dividing switchboard, shown in Fig. 2. The length of cable between collecting and dividing switchboards is 220ft., or 440ft. for outgoing and returning current.

As regards the collecting switchboard it will not be necessary to repeat the description given in our article on the light at Berechurch Hall. Readers will understand the arrangement from the drawing, bearing in mind that, in each group of four terminals seen at the lower edge of the board, the two inner ones receive the leads from the brushes, and the two outer ones those from the terminals of exciting coils or the field magnets.

It may at first sight seem that by thus bringing every lead to the switchboard an unnecessary amount of cable is used, as the object could also have been obtained by simply joining all the positive brushes by a stout wire laid direct on the dynamo platform; but this plan, although not requiring such long leads, would require contact breakers between each positive brush and the joining wire, which would be a source of danger. It will easily be seen that were any contact breakers left open by mistake, and the dynamo then switched into circuit, there would be a reversal of polarity and burning up of the machine. In the form of switchboard designed by Messrs. Crompton such an accident is absolutely impossible.

To the left of the board is placed a Siemens dynamometer, by which the current given off by any single machine, or by two or more machines collectively can be measured. On the right of the switchboard is placed an arrangement for reversing the current. This is not an ordinary reversing switch, as, with the heavy current of 300 to 400 amperes, such a switch would heat too much. It consists of two pivoted contact pieces, which are pressed on to the terminals by large mill-headed screws. Thus a very close contact is ensured and heating avoided.

The current enters the dividing switchboard at *a*, and leaves it at *b*. The arrangement of the different connections will be clear from the drawing. An ammeter is placed as shown, and so connected that the current going to any part of the building can be made to pass through it by simply turning the handle of the corresponding switch. Our illustration shows, for instance, the switch of Court 14, so placed

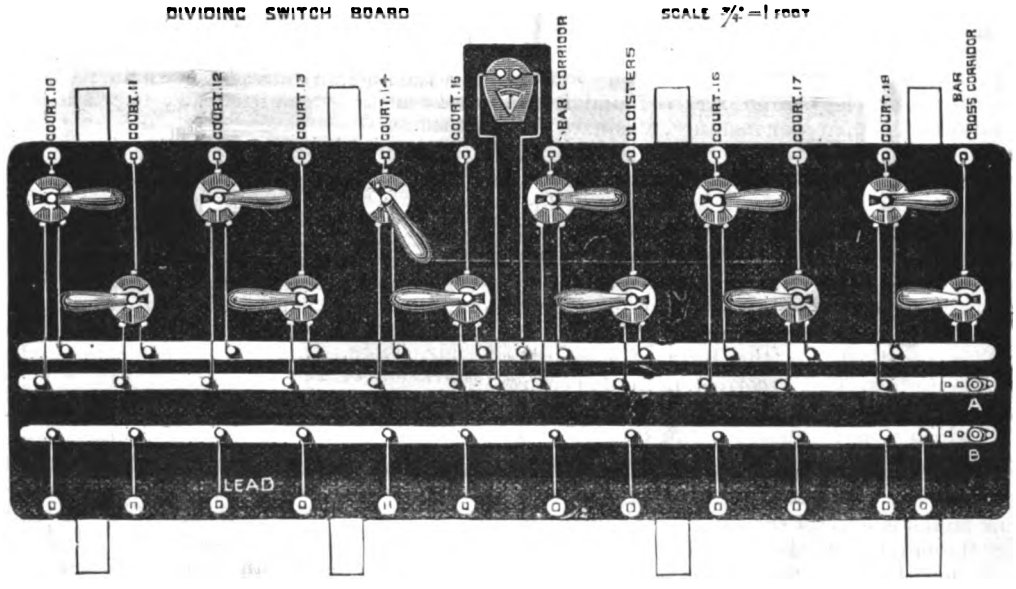

Fig. 2.

that the current flowing to that court is being measured. The leads are carried in grooved planks, and are so arranged that in no place does one lead lay across another.

Lead cuts out are provided in switchboards as shown.

A special arrangement deserves mention by which the driver in the engine house can see at any time to what degree of brightness the lamps in the courts and corridors are being excited. It will easily be understood that, although the dynamos are self-regulating, and, therefore, keep up a constant difference of potential on the collecting switchboard, yet the difference of potential on the dividing switchboard must be less by the electromotive force required to

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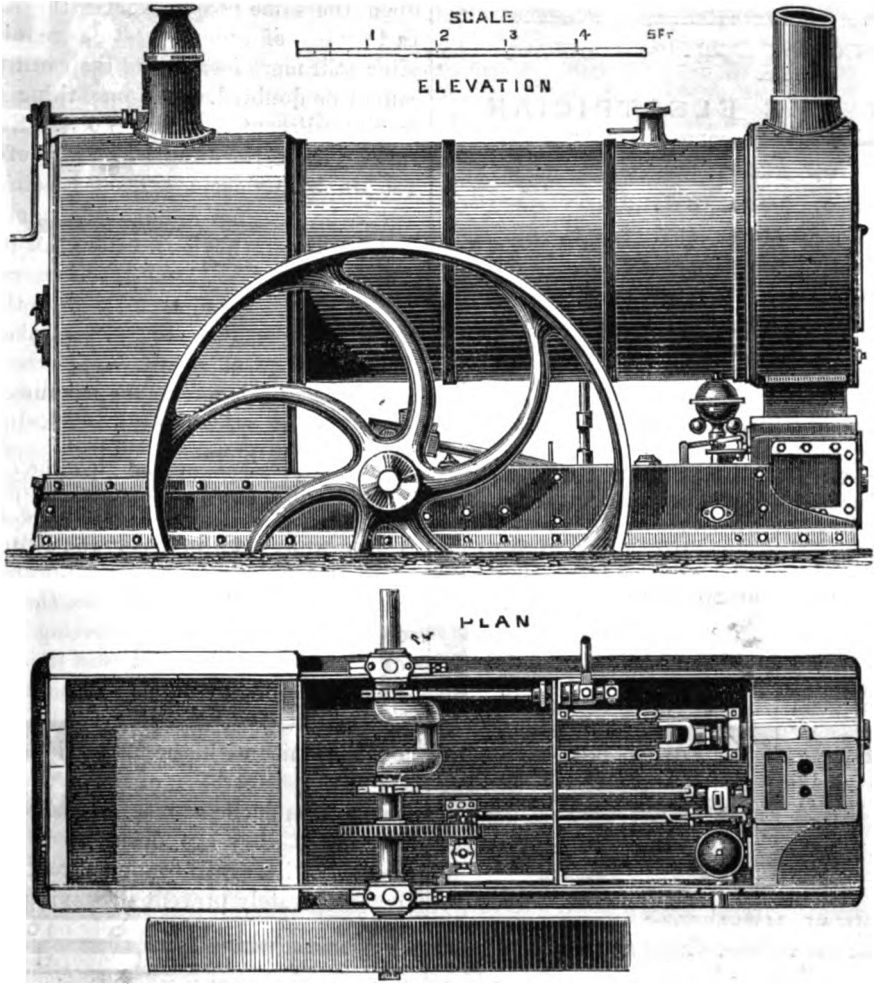
overcome the resistance of main leads. This loss of electromotive force again is not constant, but depends upon the current flowing—that is to say, upon the number of lamps which happen to be burning at any given time. In all there will be 12 circuits fed from the dividing switchboard, and equal brightness of all the lamps is obtained by so proportioning the resistance of branch leads that exactly the same E.M.F. is lost in each of the 12 branch circuits. Thus as long as the E.M.F. at the dividing switchboard is kept up to its proper value all the lamps in the building will give the right amount of light. But that this should be the case the electromotive force at the collecting switchboard must be slightly varied in accordance with the amount of current sent out. This is obtained by a slight variation in speed.

In order that the driver may know what speed to run, four Swan lamps are placed in the engine house, and are fed not direct from the dynamos but from a pair of No. 16 insulated wires brought back to the engine house from the dividing switchboard in the crypt. The loss of E.M.F. in this No. 16 wire feeding four lamps is exactly the same as that in each branch circuit in the building feeding from 22 to 30 lamps, and, therefore, the four lamps in the engine house will, at all times, have the same degree of brilliancy as those in the courts. They serve, therefore, as a guide to the driver, by which to regulate the speed of the engine.

The lamps in the engine house fulfil the same office, in fact, in connection with the electric light as the gas burner does at the gasworks—the luminosity of the lamp in the one case giving the engine driver an indication of the speed required, the luminosity of the gas indicating the pressure required.

DAVEY, PAXMAN, AND CO.'S SEMI-FIXED ENGINE.

We herewith illustrate a semi-fixed engine built by Messrs. Davey, Paxman, and Co., of Colchester, and used as the motor for driving the dynamos at Berechurch Hall. This firm has been giving some attention to engines for electric purposes, and modifications in the designs for the ordinary engines have been made for the special requirements. Our illustration explains itself, but these engines are made with either double or single cylinders. The working parts are under the boiler, in order to obtain steadiness. The bearings are extra long and of gun metal. The crank shaft is of steel, and takes the flywheel on either side. The piston, valve rods, &c., are of steel, and have the working parts case-hardened. The boiler is of the ordinary multi-tubular type, well made of the best materials, and having about 20 square feet of heating surface per horse-power. The fire-box is of mild steel. The engine is fitted with sensitive governors. Engines of this type have been carefully tested and found fairly economical. We believe Messrs. Crompton and Co. intend to use two similar engines at an installation now in progress. It is a sign of progress that our engine builders should devote their attention to the designing and construction of a special class of engines for electric light purposes. Like some other makers, Messrs. Davey, Paxman, and Co. have issued a special catalogue describing and illustrating their construction of engines for driving electric light machinery, and, no doubt, their well-known excellency of construction will direct the attention of engineers to engines of their build.



Davey, Paxman, and Co.'s Semi-Fixed Engine.

BRUSH MIDLAND ELECTRIC LIGHT COMPANY.—The petition which was recently presented for the winding up of this company was withdrawn last week, the company paying costs.

NEW CABLE.—News from the colony of South Australia says that a cable has been successfully laid between Yorke's Peninsula and Ironbridge Lighthouse.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All communications to be addressed to 396, *Strand, London, W.C.*

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ANNUAL MEETINGS.

The aptitude of the English people for self-government has been often commented upon by foreign critics; and our business ways of procedure, when common objects are aimed at by means of friendly combination, are admired even by nations most inclined to disparage us. If the net result is seldom brilliant, it is always substantial. The solid advantages we derive from patient, united, and disciplined effort more than counterbalance the absence of those startling, but less durable achievements, which impatient, premature, or ill-regulated genius may boast of elsewhere. If we do not advance by leaps and bounds, we cover quite as much ground, and do not tire so soon. One chief cause of this is, as foreign observers have noticed, our attachment to forms of procedure. However superfluous they may seem to be in given circumstances, we gravely go through with them as though they were a religious duty; and however ridiculous or vexatious they may appear to be at times, we submit to them without a smile and with hardly a murmur. All this because we have learnt by long experience that forms help us to realities, and that to conduct a meeting according to traditional usage, with none of the formalities omitted, when there is no occasion for them, is most excellent training for the serious occasions on which they really are wanted.

One of the traditional usages to which we are much attached is the annual meeting. The utility of the annual meeting need not be dwelt upon; indeed, it were better not to dwell upon it, for it is one of those things more beautiful as well as more easy to imagine than to describe. One hears a great deal that we knew before, and much beside that we could just as well have waited for a little longer; we are told with more or less candour the exact condition of affairs, which condition is not in the least affected by being talked about; the officers have all done their duty and are dutifully thanked; then the officers for the ensuing year are duly chosen, the choice, by strange coincidence, always falling upon the same people, or else the same people's nominees. In the case of annual meetings required by statute, they are often still more formal, but their utility, or contingent utility, cannot be doubted. For one thing they afford outlets for possible discontent and protest. Except for contingencies such as these, the annual meetings of societies like that of the Telegraph Engineers and of Electricians would hardly be worth the holding. We mean this, of course, from the immediate and more obvious utilitarian point of view. Only on the broader principles of tradition can any good be seen in asking people to ballot for officers the election of whom is made sure by the very steps taken to give the ballot an appearance of a popular election, whilst in reality the whole business is a foregone conclusion. One of the last trying ordeals of a retiring president is to keep his countenance while he announces that certain gentlemen whose familiar names he deciphers with apparent difficulty have been elected on the council by the votes of the members of the society. It may be well to keep up appearances, and it will be seen we are strongly in favour of appearances; but while we are about it we might as well do the thing thoroughly. The society we are just now referring to has, for two or three years past, delayed sending out the balloting papers until the contingency of any opposition on the part of the members was entirely past. This is a needless provocation, which does not harmonise with the national prejudice in favour of law and order. Members of learned societies are, it may be assumed, as docile as members of vestries and corporations, but unless they are different in other respects they will some day kick against going through a formality which they are deliberately prevented making real. Continued reverence for forms depends entirely on our reverence for the things they signify. The ballot papers lately received by members of the Society of Telegraph Engineers and of Electricians signified nothing, and could not by any possibility signify anything.

To the elections themselves, however, hardly any exception has been taken. One really good element in the annual meeting is when it brings a change of officers. That society must be very humdrum indeed if the introduction of fresh officers, new blood as it is called, does not infuse new life into its affairs. However slow or badly managed it may be, there is hope in the changes impending, and its members learn to be patient. No society can afford long to dispense with the revivification which the annual elections effect in its composition; and the society with whom we are more particularly concerned is fortunate in having a constitution which makes these annual changes compulsory. A fresh president, one new vice-president, and several new members on the council look almost revolutionary, and we quite appreciate the difficulty sometimes experienced in getting the annual vacancies adequately filled. But the principle is good, and

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we believe it will work well so long as the general body of members do not suspect that they have no voice in the matter. We have only heard one complaint as to nominees of the council this year, and this was because of the paucity of representatives of electric lighting enterprise. Time, however, will mend this defect, if it is a defect, the remedy being, probably, forthcoming at no more distant date than the next annual meeting. The anomalous position for some time past of one *de facto*, though not *ex officio*, member of the council has been this year set right, affording an illustration of what we mean by the value of patience as taught by our annual meetings.

For so young a society its position and standing in public estimation are almost unprecedented. From year to year it has gone on rapidly increasing its number of members and adding to its prestige. One cannot help regretting that some valuable contributions to electrical science find their way to a still younger society devoted to purely physical subjects; but this, though unavoidable at present, may be rectified in time if electrical science is allowed to maintain its due prominence in the elder society, now that its title is enlarged so as to embrace the physical as well as the engineering aspects of electricity.

In two other respects the society has been especially privileged. Its place of meeting is not only handsome and commodious, but, thanks to the liberality of the Council of Civil Engineers, it costs the society absolutely nothing. But for this circumstance its funds would not be in the flourishing condition they are now reported to be. A spacious, luxuriously-appointed meeting-house is an attraction of itself, and, as the hon. treasurer in tendering thanks for the use of it remarked, is a practical help to good meetings and good debates. To munificence of a more personal kind the society owes its library, a quite unique collection to begin with, and one which, so contagious is liberality, promises to become one of the best and completest technical libraries in the kingdom. In all points, therefore, the Society of Telegraph Engineers and of Electricians is to be congratulated on the report it was able to present at its eleventh annual meeting. The fact is gratifying also to our readers, who are interested more or less in the welfare of this representative society. To one and all alike we wish that a merry Christmas may reward them for the toils and anxieties of the year.

A CONTRIBUTION FROM A LADY SUBSCRIBER.

There was a kindly field Magnet,
Who loved with all his might
A wild revolving Armature,
With commutator bright.

He tried to woo his fair sweetheart
By messengers of love,
By lines of force sent right and left,
Below and from above.

Love's labour lost! Proud Armature
Threw Magnet in despair,
With reckless whirl she thwarted him
Till he no more could bear.

His field got shifted more and more,
In vain he cried, "Hold on!"
It was too late, her coils were burnt,
Fair Armature was gone!

Now, maidens, take this tale to heart,
And never slight your swains;
Lest hurting them you hurt yourselves—
As Dr. Lodge explains.

CORRESPONDENCE.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your last issue appear nearly three columns under the above heading in the form of a letter from Mr. R. D. Smillie, electrician, Glasgow. I do not presume to doubt that Mr. Smillie is an electrician—he, himself, has said it—but I will venture to assert that he knows next to nothing about the subject he has taken in hand. His experience of the Blake transmitter must either have been extremely limited or has borne strange fruit. He begins by saying that he has discovered that Professor Blyth and "the distinguished physicists" who agree with that "learned professor" (the quoted words are your correspondent's) are entirely mistaken in their assertion that the resistance of hard carbon does not diminish under pressure. And then he proceeds to give full details of the experiments upon which he founds his conclusion; in other words, he proceeds, with much pain and circumlocution, to prove himself in the wrong, and Professor Blyth in the right! The peculiar action of the microphone, as explained by Professor Hughes, is due to the varying pressure, and, consequently, varying electrical resistance, caused to exist between two conductors, lying in slight or loose contact, by agitation in the medium surrounding them. Professor Blyth has amplified this explanation, not contradicted it. He has proved that one conductor may jump slightly clear of the other; but, inasmuch as a current is passing between them at the time, electrical communication is not broken, owing to the formation of a minute arc, or a number of minute arcs, simultaneously with the momentary interruption of the contact. He illustrates this fact by means of an experiment—that of a continuous arc due to 20 Grove cells—which has earned the ridicule of Mr. Smillie, but which is not the less instructive on that account. What does your correspondent do to prove his assertion that microphonic action is due to compression of the carbon and not to variation in the resistance of the contacts? He takes a microphone, the conductors of which are pressed together with a force of 45 grains. He blows upon it with bellows, and tickles it with a bristle plucked from a broom, thereby causing one of the conductors to press against the other with a force greater than 45 grains. What happens? Precisely what Professors Hughes and Blyth tell us—*i.e.*, the resistance of the contact between the conductors is diminished. He ceases to blow, and to tickle, and lo! the contact re-acquires the resistance proper to a pressure of 45 grains. Is there in all Mr. Smillie's three columns one iota of proof that the carbon was compressed? Not one. Let Mr. Smillie remove the carbon button from his Blake transmitter, and replace it by a metallic button. Let him bring his platinum stud against the new button gently, so that the current from a No. 2 Leclanché will just pass, and no more. Then let him blow upon and tickle his diaphragm as before, and inform you, Mr. Editor, whether he thinks the diminished resistance which he will observe *is still due to the compression of the carbon button.*

I do not know whether the remainder of the letter is worth reviewing; but it is amusing to note with what innocence Mr. Smillie publishes his four "deductions" as though they had not—the first, of course, excepted—been perfectly well known to every telephonist since 1878; and how completely he must have misunderstood Professor Blyth's paper when, in the last paragraph, he attributes to him an intermittent contact—*i.e.*, make-and-break-theory.—Yours, &c.,

London, Dec. 18, 1882. LOOSE CONTACT.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If Mr. R. D. Smillie is correct in his deductions from his experiments with bellows, bristles, and breath, what is there to prevent us from doing away with the platinum stud P altogether, and joining R to B in the primary circuit, in the same way that S is connected?

I, for one, see nothing in his experiments that is out of

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harmony with the theory of loose contact, which is the same as a bad joint in a wire—it increases its resistance. Pressure on the microphone makes the contact closer, hence the greater deflection of the needle, which regains its former position as the pressure becomes less. This pressure on the microphone acts the same as the wire, in having the defective joint improved, *i.e.*, the contact becomes improved, calling forth more energy from the battery, as the needle shows. If there were no make and break taking place, a piece of carbon, to which two binding screws were attached, ought to be sufficient to speak with. As the experiments are not yet complete, may I suggest that he constructs one as stated, to forward with his next batch.—Yours, &c., J. RATHBONE.

COMPOUND MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: To use one of those witty Americanisms that, whilst not slang, have all its piquance, your contributor, Mr. Gisbert Kapp, in attributing to Messrs. Crompton and Co. priority in the practical development of dynamos wound on the shunt *and* main circuit principle, is a little "too previous." The first to practically develop this idea was Mr. C. F. Brush, the eminent electrician, who has brought Cleveland, Ohio, into notice as an electrical centre. He wound the main circuit on the same magnets as a shunt circuit, which he terms a "tenzer." But he does this for a special purpose, and that is in electro-plating machines to prevent the back-action of the bath depolarising the electro-magnets, to which the chief generative effect is due. His purpose was not to obtain a constant electromotive force; nor could it have been obtained by his arrangement. In 1878, when I wrote my book on electric lighting—now far behind the times—I gave mention in a chief place to the Brush machine, then unknown here, because I considered it to be the machine of the immediate future, as it became, and I then pointed out that this principle of double winding was applicable to the purposes of light and power. Later on I built a machine wound on this principle, and followed it up with others, not because the first was a success, but because it was a failure, the cause of which needed working out, as it was not, as a failure, at all in accord with (subsequently successful) theory. In these failures I wound my shunt-magnet circuit on the *same magnet cores* as my main magnet circuit. The result was a flickering unsteady light, and an unaccountable breaking down of insulation in the shunt circuit coils. The reason was hard (for me) to find; but being found it is very easy to give. Wound thus, the main-circuit formed a primary, and the shunt-circuit the secondary of a powerful induction coil, the potential of which, it is easy to see, became in this secondary enormous. For instance, suppose, as was the case, an arc lamp burning in the main-circuit; sudden extinction, by separation or breaking of the carbons, developed powerful secondary currents in the shunt-magnet circuit, which not only affected the working of the machine, but pierced the insulation of the wire, and besides were dangerous. Indeed, on a parallel wound wire long and dangerous arcs could be obtained by severance of the main circuit. This palpable result of experience should be, with the dates of my patents, some evidence to show that the Messrs. Crompton were *not* the first to work out this idea into practice. I cannot spare Mr. Kapp this contradiction, because, in quoting Professor Bosanquet's letter, he would have found reference to the statement, from the manager of the company controlling my patents, to the contrary of what he asserts. So far I consider his neglect wilful.

With your permission I will state how, after much expensive experiment and study, I got free from this defect I have mentioned. The expedient I adopted is to wind the shunt magnet circuit and main magnet circuit on *separate* magnet cores; and since then I have not had the least trouble. It is easy, by a simple alteration of connection, to keep either the electromotive force or the quantity of current constant. The method has been applied to the Gramme machine with good results, but among the best results were those obtained with a machine, so altered, of Mr. James Wood's invention, and made by the Fuller Company—a machine that of itself deserves to be much better known here both as a very light-weight and effective machine.

This method of winding is described in my American patent, No. 242,644, applied for March, 1881—that is, in the spring of the year *previous* to that mentioned by Mr. Kapp as that of his work under Messrs. Crompton's direction; and it also has been patented in all European countries.

Whilst I deprecate the assumption made by Mr. Kapp I should be open to accusation of great oversight if I were not to acknowledge the very candid reference to my name made by Professor Bosanquet. So definite and noble recognition of another's priority in one's labours is unusual, unfortunately, at least in my experience. I should feel corroboration on my part uncalled for, as to the practical reliability of Mr. Bosanquet's investigation, were it not that Mr. Kapp attacks it.

There are obviously three heads under which the subject may be considered (*a*) That in which the most of the excitation is done by the shunt-circuit, and only a certain proportion by the main, (*b*) in which the circuits play an equal part, (*c*) in which the shunt-circuit plays only an initial part.

There are uses for each of these arrangements. Mr. Bosanquet's remarks apply to (*a*) as far as the limit of (*b*), so far besides as relating to the maintenance of a constant E.M.F.

But, beyond these three heads, a much larger field for inquiry is opened up by the use of separate cores for the main and shunt circuits—a field that I have been exploring for the last three years with all the aid of hard mathematical study, as well as with large assistance from those essential "exhaustive and careful experiments" Mr. Kapp arrogates to himself and his friends. For instance, we may make all the S poles of our machine come within the magnetising influence of the shunt circuit, and all the N poles within that of the main circuit, or we may differently apportion them. It is possible and easy thus to make a machine that shall give either constant E.M.F. or C, with varying R, within certain limits, *and above or below those limits cease to give any current at all*—an arrangement peculiarly safe where enormous currents are dealt with. And we can make the limits of constancy so narrow as the machine becomes almost galvanometric.

Permit me to add that these results have been obtained practically only with expenditure of money greater than a single individual would be likely to undertake, and that the proprietary vests, as regards the patents for Europe, in the Higgs Electric Light and Power Company; that this company, through its *concessionaires*, are building, and have built, several machines, but have purposely and stringently avoided advertisement for business reasons; and I think the chief of this ground is covered by the patents of Brush and myself. As business men who have laudably assisted in developing new ideas, I asume my friends will *not* make a present to the world of the scientific facts I have discovered for them during my investigation. Hence my personal reticence on the subject in technical journalism.—Yours, &c.,

Paris, Dec. 18, 1882. PAGET HIGGS.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I was present last night at a lecture given by Mr. Reckenzaun, the well-known electrician to the Electrical Power Storage Company, at the Limehouse Town Hall, and was pleased to see a large and attentive audience listening to his explanations, and taking great interest in his excellent and instructive experiments.

The principal feature of the evening was the experiments made with *secondary batteries*, and I have no doubt that a few words on the subject will interest your readers.

These secondary batteries were of the Sellon and Volckmar type, and, as far as I can learn, were charged at Millwall, and carted to Limehouse to be used there, before the audience,

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for driving a lathe, sewing machine, for lighting an arc and several incandescent lamps.

This is, I believe, the first time these secondary batteries have been shown in public since their exhibition at the Crystal Palace, and there cannot be much doubt that they are the only ones that have left the stage of laboratory experiments for the sphere of useful and important commercial commodities.

A very noticeable and important feature also was the lighting of the Pilsen arc lamp. I believe that this is the first time that an arc lamp has been successfully lit up by accumulators, and I think that if Mr. Reckenzaun would kindly favour the public with some details of the practical construction, and his no doubt great experience of the working of the Sellon and Volckmar battery, and also of his arrangements for lighting arc lamps by their means, it will be of great public interest.—Yours, &c.,

29, Aldermanbury, E.C., BLYTHE UNWIN.
December 14, 1882.

A TELEGRAPH LINE WITHOUT INSULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Pressure of business has prevented me replying to "M. Practical" sooner, or I should have been pleased to do so, and should thus have saved your (2) correspondents their intense anxiety on my behalf.

I am surprised to find that a telegraph engineer with such a knowledge and experience as "M. Practical" would appear to possess should have discovered for the first time from my letter that it was possible to work a telegraph line nearly 200 miles long without insulators, especially in Japan, where, as I stated, the climate is so favourable to insulation. They were worked with Siemens's best inkwriters, which a man of "M. Practical's" experience should know are also usually supplied with very sensitive relays, our case being no exception to the rule, each relay being most carefully made and wound to 300 ohms resistance.

How a telegraph engineer with the extensive knowledge and experience claimed by "M. Practical" can have learned also for the first time of the existence of a water battery is curious, but for "M. Practical's" information, who is evidently unaware of the fact, I may say that the water battery was extensively used some fifteen or sixteen years ago in cable experiments. A quart-sized cell made up of water alone gave an E.M.F. of ·936 volts, while the internal resistance was 19 ohms.—Yours, &c., J. O. F.

IS THE MICROPHONIC CONTACT AN "ARC?"

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Professor Blyth's Experiments on Microphonic Contacts, p. 42, he comes to the conclusion that the action of a transmitter can be analysed as follows:—

"It is a break and make like the Reis, with the addition of material filling up the gaps."

I beg to propound the question whether, electrically speaking, a filled up "gap," and, therefore, an "arc," is indispensable in the action of the transmitter.

Some time ago I proved that if a Blake transmitter was enclosed in an ordinary vacuum its resistance was less by two-tenths of an ohm, and that this two-tenths represented the thin stratum of air between the contact electrodes.

Now, while it is possible with a comparative large electromotive force to produce what is termed an "arc," I cannot believe that the two volts of a Leclanché cell acting upon a resistance of about five ohms of a Blake transmitter can produce this phenomenon.

But, of course, while the sound is acting the stratum of air becomes wider, and its resistance increases enormously; but even then it merely represents so much resistance, and not necessarily an "arc" meaning a discharge of particles.

The very fact that at a loose contact there is a "mechanical gap" between the parts in "so-called" contact, which is filled up with air of two-tenths ohm or more resistance, does not make it an arc any more than if the "gap" was filled up with other matter representing that resistance. The great advantage of air as a contact medium is that it is highly elastic and does not stick to the electrodes as a liquid would by capillary attraction under similar conditions.

Furthermore, the condensation of air upon a carbon surface may well account for why this material is so well adapted to the purpose of a transmitter.

Professor Blyth proves the correctness of the aërial contact idea as always advanced by me, and shows, too, the experiment of transmitting by means of an arc; but that does not prove that an arc is necessary.

I once examined a very hard and highly polished carbon button which had been in constant use in an all carbon loose contact transmitter (with one cell gravity) for ten months, and I could not discover the point of contact, showing that no deterioration had taken place. Yet many million times had this contact vibrated and faithfully transmitted speech. Is it possible that in this case a transfer of carbon particles, an "arc," had occurred?

It is, however, certain there was an air layer continuously changing its resistance between the electrodes.

Now, if two electrodes separated by an air resistance of two-tenths ohm are called in contact, why are they not so when this resistance is 20,000 ohms? and if this is not a contact, where does it commence to be an "arc" unless there is a transmission of particles?—Yours, &c.,

E. BERLINER.

MR. CROMPTON'S APPLICATION OF THE SWINBURNE WINDING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Though no one will grudge credit to the first maker of compound dynamos in any particular country, I think Mr. Crompton did not introduce the idea into England, and was not the first to try the system, or to use it commercially. Though it is highly improper to talk of one's own doings, I tried the system early in February, having previously independently invented it, and described it to Messrs. Swan and Co., of whose French factory I had charge, my letters fixing the dates. A dynamo having been sent accidentally wound with the wrong size of wire, this system was applied with success, and the dynamo used. I wished to patent a dynamo of which this winding was the chief characteristic, but found that Mr. Brush had used a fine shunt wire as a "teazer," I believe, to prevent reversal of a machine for plating, from which circumstance the invention was credited to that eminent inventor. As the rest of my machine may yet be protected I will hardly be expected to describe it; but it is evident that the change of the ratio of work done in the bobbin of a shunt machine to the work done outside is not alone to be considered. As will probably be dealt with in M. Kapp's second paper, the points of greatest magnetisation are moved when the current in the bobbin is altered; and this current also induces a counter E.M.F. in the wires of the field-magnets. This last phenomenon seems to have been first mentioned only quite recently in England, though I have lately found that M. Joubert wrote of it in 1881, and will, no doubt, again discuss it in his forthcoming work. Having to instal a large Swan works in America, I asked Mr. Brush if he would kindly have compound dynamos wound for me. I have not the figures of these, but think the variation in speed necessary was only 2 or 3 per cent. up or down. The application of this winding to give a uniform E.M.F. at the terminals of the machine, which will probably soon be the regular way of winding dynamos, seems far more important than that for getting a uniform C for lamps in series. To get uniform E.M.F. on work with resisting leads interposed is more troublesome. A machine should not only adapt itself economically to its work, but should compensate for the ordinary irregularities of the driving engine. I have reason to think this can be done automatically with practical accuracy, without shifting the brushes or using any mechanical regulators. My extreme modesty prevents my suggesting, or even remotely hinting that, if I first introduced the sys-

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tem of double-winding self-exciting machines, it be called the "Swinburne Winding," so I will not.—Yours, &c.,

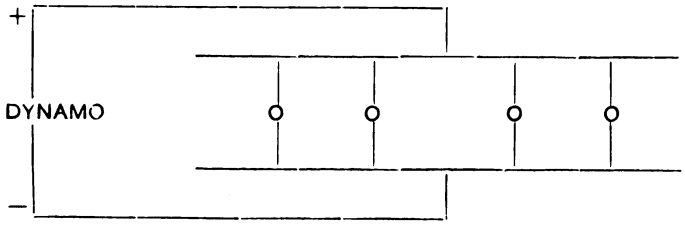
JAS. SWINBURNE.

December 16. Late of Swan I.E.L.Co., U.S.A.

INCANDESCENCE LEADS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have carefully read Mr. G. Kapp's paper on incandescence leads in the number for December 9th. It occurs to me that a mode of more equally distributing the current



so that there should be less difference in E.M.F. between the lights nearest dynamo and those at the far end of leads would be to arrange matters as in this diagram, instead of beginning to draw off E.M.F. at the nearer end of circuit.—Yours, &c., W. T. F.

[We should be glad if correspondents would remember that our columns are open to scientific discussion, and that personalities should be avoided. We think that some of the letters in this week's number bear on the personal rather than the scientific.—ED. *E.*]

MR. W. T. HENLEY.

Mr. William Thomas Henley, the well-known telegraph engineer and contractor, of North Woolwich, who died on Wednesday, the 13th inst., in his 69th year, was one of the early pioneers of practical telegraphy in this country. Mr. Henley was born at Midhurst in Sussex. After receiving a good education he was brought up to the leather trade, but not liking that business, at 16 he left the country and came up to London to seek his fortune. He began as light porter at a silk mercer's in Cheapside, and afterwards worked in the docks as a labourer for some years. Meanwhile he taught himself the trade of a philosophical instrument maker, and at 24 years of age he started in business as an electrical instrument maker. When Professor Wheatstone brought out his first electric telegraph Mr. Henley was employed to make the apparatus and assist at experiments. When the first Electric Telegraph Company was formed in 1846 Mr. Henley did a large amount of work for them, but having partially executed a large order for the company, which they for some reason cancelled, he went to law with them, and they consequently gave him no more work. He then invented the magnetic telegraph, and in 1852 formed a powerful company, called the British and Irish Magnetic Telegraph Company, to whom he sold his patent for £68,000. Lines were laid by Mr. Henley for this company underground between London and Carlisle and between Dublin and Belfast. The Magnetic Company, of which Mr. Bright (now Sir Charles) was the engineer, became a powerful rival to the Electric Telegraph Company, and Mr. Henley continued to supply the company with his magnetic instruments.

In 1857 Mr. Henley began making submarine cables at Enderby's Wharf, East Greenwich, making in that year 30 miles for the straits between Ceylon and the main line, and nine miles for Egypt, and in 1858 he made 240 miles, at the same works, for Bass Straits, between Tasmania and Australia. In 1859 he built the well-known cable factory at North Woolwich, and in 1860 made the 365 miles for joining the Balearic Islands with Spain. He made several cables of shorter length in 1861, and in 1863 made 1,651 miles of heavy cable to the order of the Indian Government for submergence in the Persian Gulf. The core of this, and indeed of all the others previously, was supplied (in this case to the Government) by the Gutta Percha Company, which soon afterwards, combining with Messrs. Glass and Elliot, formed the Telegraph Construction Company. Thus Henley, having no means of obtaining core, had to make permanent arrangements with the Construction Company. From a very early date at these works he commenced to galvanise wire and other ironware, and soon after set up machinery for drawing wire, and drew all his own wire. Later on still he commenced rolling his own iron, and making also steel wire, and covered copper wire with india rubber. Altogether he manufactured here some 13,000 miles of cable. Besides these works, which covered some 18 acres of ground, and where he at one time employed as many as 2,000 men, he had iron works in Wales and collieries; and at one time he had three ships—"The Africa," "La Plata," and "Caroline," all fitted for telegraph cable laying, and from which ships many cables were laid at Mr. Henley's risk as contractor. For some six years he was making profits of £80,000 a year, but we believe the iron works in Wales were the beginning of misfortunes, and in about 1874 Mr. Henley failed for about £500,000. In 1876 a limited liability company was formed to carry on the work under the title of W. T. Henley and Company (Limited), of which Mr. Henley was managing director, but this eventually was wound up, the bulk of the ground and works becoming the property of the Telegraph Construction Company. This portion was closed, and now remains idle. A portion of the works was formed into the present company in 1880, under the title of W. T. Henley's Telegraph Works Company (Limited), of which company Mr. Henley was a director up to the time of his death. At these works he manufactured his ozokerited india rubber core, which was one of his latest patents of consequence.

He was an exhibitor, and obtained a council medal for electricity and magnetism, at the Exhibition of 1851. He was early in the field as a maker of electric light apparatus, having made machines for the Alliance Company in 1849.

Mr. Henley was altogether one of those extraordinary examples of self-reliant and self-made men. He was eminently inventive and enterprising, and thoroughly practical. He was devotedly fond of his works and workmen, and could not tolerate anybody between himself and his foremen, and indeed he would often override a foreman's discharge of a man. Even when making the large profits we have mentioned, his own personal expenditure was a mere nothing, as he lived in the simplest way possible, and was nearly always at his works night and day. As soon as he got money he spent it on increase of works or plant. His workmen were devoted to him, and he made friends to the last amongst all grades, and by some hundred of these his funeral on Monday last at Kensal Green Cemetery was attended.

ELECTRIC LIGHTING IN SPAIN.—A correspondent of *L'Electricien* gives some account of the doings of the Sociedad Espagnola de Electricidad in a recent issue of that journal. The company, it appears, has a capital of 20,000,000f. (say £800,000), M. Dalman, of the firm of Dalman and Sons, of Barcelona and Madrid, opticians, &c., being the managing director. M. Dalman was the first to introduce the Gramme machine into Spain, some eight years ago. The company's works at Barcelona, in the Calle del Cid, utilise 140 horse-power in the production of Gramme machines, and arc lamps, Maxim lamps (of which latter they can turn out 1,000 per day), and Kabath accumulators. About 200 workmen are employed. The company are erecting a central station, which will occupy some 7,000 square metres, close to the centre of the town, where they will have at their disposal 2,000 horse-power. They use Root boilers and Corliss engines. The company has recently erected 15 Gramme arc lamps on the quays of the town. They are also making provision for a large central station in Madrid, and have several lights already going there in cafés and other places.

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METHODS OF EXCITATION AND OF AUTOMATIC CONTROL IN DYNAMO-MACHINES.

BY PAGET HIGGS.

The method of exciting the electro-magnets of dynamo electric machines usually adopted is that due, as far as present evidence goes, to Hjorth. It is too well known to need description, and is generally termed the method of "mutual accumulation." The principle of mutual accumulation extends, however, to all methods whereby the electro-magnets are excited by the armature of the same machine. This method, illustrated diagrammatically in Fig. 1, may for the purposes of this paper be termed the *ordinary* method; the electro-magnets M are in the same circuit as the armature A. LL^1 are the terminal screws of the machine.

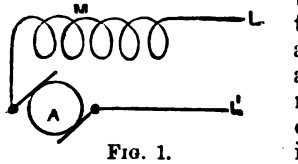

FIG. 1.

There is an earlier method of exciting the magnets of machines, due to Sinsteden (*Pogg. Ann.*, 1851, vol. 84, p. 186) the current circulating in the magnet-coils being wholly produced by a auxiliary machine. This is shown in Fig. 2, but the auxiliary machine is omitted. The method is to-day largely used in connection with some so-called regulating systems, the regulation being effected in the main or armature circuit by alteration of the strength of the exciting current from the auxiliary machine. Such a system of regulation needs the use of a regulator in the main circuit controlling the introduction and withdrawal of resistance in the circuit of the auxiliary machine, as well as a second machine, a somewhat costly and clumsy arrangement, likely to introduce error or failure from the multiplication of the apparatus.

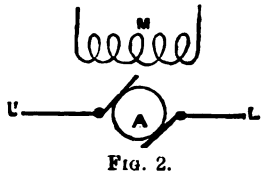

FIG. 2.

Very recently M. Marcel Deprez has introduced a combination of these two methods in a system wonderful for its simplicity and for the clearness of its elucidation and its numerous applications. M. Deprez has not only demonstrated the theory of his arrangement to be applicable in practice, but has carried out several important applications. This system, Fig. 3, consists in winding the electro-magnet inductors with two equal wires side by side; one circuit is traversed by a current produced by an auxiliary machine, the other by the current produced in the revolving armature of the machine itself. The first circuit is used to maintain an "initial field," the second develops the full power of the inductors in the usual fashion. To maintain the electromotive force constant, a certain speed is only further necessary to be found; to maintain the quantity of current constant the inductors are arranged in a derived circuit from the main circuit, and the same speed gives the desired result, however, in either case, the resistance of the external circuit may be varied.

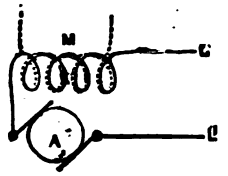

FIG. 3.

Thus, without any auxiliary apparatus whatever, except an exciting machine, besides the ordinary dynamo, M. Deprez's system affords a perfect system of regulation, and one by which, with simple manipulation of a commutator, either the electromotive force or the quantity of current may be kept constant at will, no matter how the resistance of the external circuit may vary.

In December, 1881, this system was fully described in the pages of *La Lumière Electrique*. In March of the same year I applied to the U.S. Patent Office for letters granted in June for an arrangement of the inductors of a dynamo machine enabling the same result to be obtained with a single machine without any auxiliary exciter. It is scarcely necessary to add that my experiments had been made long before.

Before proceeding to describe this method I would remark that Wheatstone in his early paper (1867) pointed out the considerable advantages of the "shunt" method of winding dynamo machines, an arrangement that has only recently been recognised. Mr. Edison, were it not for this manner of arranging his machines, would probably be in the same position as regards the excitation of a low-resistance armature as are most makers of electro-plating machines who have not yet adopted this way of winding. It is, in fact, the only effective manner of winding such machines; it is shown in Fig. 4. As a matter of history, it will be found that the large inductors, which now appear in the machines of the best construction, also are evident in even an exaggerated form in the machines delineated and constructed by Wheatstone, and I am able to say that this construction was not a matter of accident with him. Indeed, many of the old machines are examples of much careful thought, now claimed as modern invention. We might even refer the idea of the initial field to this category, if we accept Hjorth's (1854) description of his machine. Col. Bolton's abstract of the patent reads:—"The coiled armatures revolve between the poles of cast-iron permanent magnets, *and* of fixed electro-magnets," the principles of mutual accumulation being then detailed; and, the specification adds, "the permanent magnets may be coiled like the electro-magnets, which also will serve to make them more permanent." Here are all the requisites for an initial field, although not in a sufficiently practical form. In a specification of a patent applied for in the United States Patent Office in March, 1880, but afterwards withdrawn, I had thought of procuring an initial field by the introduction, amongst the other inductors in a machine, of electro-magnets having parts of their cores of steel, but the large dimensions required to secure practical results, and the inferior steel for this purpose to be obtained in America, early led to abandonment in favour of the previously tried idea of a combined system of electro-magnet inductors.

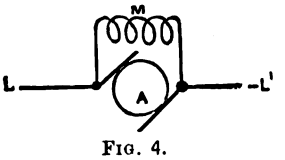

FIG. 4.

This combination system I have arranged as follows:—A dynamo machine is selected, having preferably several electro-magnets to a magnetic pole of the inductors of the machine. [Or if the machine is one in which there are more than one pair of poles, the distribution to be described is made between the several sets of magnets, as will be readily imagined.]

Some of these electro-magnets are included in a shunt circuit between the armature poles of the dynamo machine, and the *remainder* are arranged in the main circuit. The proportion of the distribution will vary according to the purpose and the electromotive force of the machine.

Fig. 5 is a diagram of the machine thus arranged.

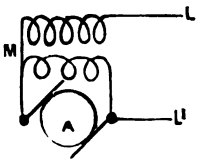

FIG. 5.

Accepting the proof given by M. Marcel Deprez (*La Lumière Electrique*, tome VI., pp. 309) as applying to this case, although, owing to the introduction of another variable, the integration can only be done by parts, we see that we have an initial field formed by the magnets of the shunt-circuit, and it is easy to find that speed for which the potential difference in the main circuit shall remain constant, however the resistance may vary. But the variation of the speed necessary to establishing this condition causes a variation of the initial field, and therefore modifies very considerably the analytic solution of the problem. Yet in practice a system of coned pulleys offers simple and easy answers to the question of what is the right speed. Referring to the diagram employed by M. Marcel Deprez, and, bearing in mind that in this case decrease in speed means a decrease in quantity of current producing the initial field as well as in the potential or ordinate corresponding to that quantity of current, it is easily perceived that a few more sets of readings have to be preserved of the E.M.F. corresponding to the several quantities of current, and that

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is the sole practical trouble which has only once to be incurred by the builder of the machine to find the proper speed.

If the inductors are so arranged as to include all those relating to the north polarity of the machine in one circuit, and all those giving the south polarity in the other circuit, a very curious state of things accrues. For we know that, if we excite only one pole of the inductors of a dynamo machine, we get practically no current, and that if we excite the poles unequally, we do not get the full force of the current due to equal excitement of both poles. The cause is easy to see. Now, suppose we arrange our shunt system of inductors to give a certain magnetic field due to a certain product of current and number of convolutions in the inductors, if the magnetic field corresponding to the other pole and circuit be not maintained at or very nearly the same intensity, the current given by the machine will practically cease. That is, it is practicable to construct on this principle a machine that shall give a current only when the outer circuit is in a normal condition; and it is unnecessary to dwell upon the enormous advantages under some circumstances to be obtained from this capability without the help of any auxiliary whatever.

Beyond the advantages that either with lamps or with motor machines driven from a machine arranged on the combined shunt and main circuit inductor principle, each lamp or motor is absolutely independent of any other on the same circuit system, so that it can be extinguished or stopped, lighted or started, without affecting the others. There is another benefit derived. Every one who has had to deal with large dynamo machines arranged on the ordinary plan must have felt, when driving with an engine that has very small surplus power, constant anxiety as to what would happen if the circuit were suddenly and wholly broken. A very serious accident once occurred to me under these conditions, resulting in nearly utter destruction of the engine, for the governor, although somewhat better than the average, did not respond with the lightning rapidity required by the electric current. In the case of the combined system, the load is never wholly removed, and the engine has the small but necessary check. A similar source of danger occurs with the simple shunt system alone, when the outer circuit is put on short circuit, as by the failure of a lamp, for then all the current is drained, as it were, from the electro-magnets, and the machine ceases its functions.

A method of distributing electrical energy has been recently patented by Professor John Perry. It consists in combining with the dynamo machine one or more magneto-electric machines or other sources that will produce in a circuit an electromotive force constant and independent of any other electromotive forces in the same circuit. When the main wires are arranged in parallel arc with an ordinary dynamo there is introduced into the main circuit a magneto-electric machine or battery, producing a constant electromotive force equal to that which ought to exist between the supply and return mains. The speed of the dynamo-machine ought to be such that the electromotive force created is proportional to the current circulating in the field magnets, or, in other words, the field in which the armature rotates ought to be proportional to the magnetising current. When a shunt-dynamo is used, Professor Perry prefers to place the magneto-machine in a part of the circuit which is quite outside the machine, that is, in the main circuit, so that the current passing through it is that which goes to the supply cable. These arrangements apply when the lamps are in parallel arc; when the lamps are in series, a shunt-dynamo machine and a magneto machine are employed. Let the shunt part of the dynamo be called M, and the armature circuit A; the two ends of A and of M are the same, and may be called the binding screws of the machine. If these binding screws are joined to the two ends of a circuit containing a series of lamps, and there be introduced a magneto-electric machine in the part A or in the part M, or if we have a magneto-machine in A and another in M, a certain speed can be given to the machine as will cause it to deliver a constant current of electricity through the external circuit, however the resistance of that circuit may vary. The constant current is that which the magneto machine or machines would produce in a circuit whose total resistance is equal to the resistance of A.

There are thus three methods of absolute control afforded the electrician, that of M. Marcel Deprez and that of Professor Perry, each needing an auxiliary machine or equivalent, and that which I have myself outlined here, and needing only one machine to attain practically the same end.

In recounting these inventions, I distinctly disclaim any desire to assert priority, even if it be my due; for I am convinced that that process which is the most practical will bring, at the present day, the best recompense to its inventor, whilst each described has its advantages.

In a future paper I will enter upon the more exact examination of the subject.

DETECTION OF METALLIC MASSES IN THE HUMAN BODY*

BY ALEXANDER GRAHAM BELL.

The subject of my present paper recalls a time of intense excitement and painful suspense. The long, weary struggle with the untimely death-wound—the prolonged suffering borne so bravely and well by the lamented President Garfield must still be fresh in every recollection. The whole world watched by his bedside, and hopes and fears filled every passing hour. No one could venture to predict the end so long as the position of the bullet remained unknown. The bullet might become safely encysted, but, on the other hand, recovery might depend upon its extraction. The search with knife and probe among vital and sensitive tissues could not be otherwise than painful and dangerous; and the thought naturally arose that science should be able to discover some less barbarous method of exploration.

Among other ideas,† the thought occurred that the bullet might produce some sensible effect in modifying the field of induction of a coil brought near the body of the President, and that the locality of the bullet might thus be determined without danger to the patient and without pain; for it is well known that induction can be powerfully exerted through the human body without producing any sensation whatever.

Upon the Balancing of Induction.

The influence that is exercised upon induction by metallic masses has formed the subject of numerous experiments by different investigators; and the principle of balancing the effects of induction on one portion of a circuit by equal and opposite effects produced upon another portion has been utilised in nearly all such investigations.

The earliest form of induction balance for this purpose appears to have been devised in Germany by Professor Dove,‡ about the year 1841, and a good description of it in the English language may be found in De la Rive's *Treatise on Electricity* (1853 edition, Vol. I., pp. 418-433)§.

Another and superior arrangement for the same purpose is the well-known induction balance of Professor D. E. Hughes||.

The static induction balance of J. E. H. Gordon,¶ though primarily intended for experiments upon specific inductive capacity, might also, perhaps, be employed in the same class of investigations.

My own attention was directed to the balancing of induction a number of years ago by the disturbing noises produced in the telephone by the operation of telegraphic instruments upon lines running near the telephone conductor.

The difficulty was remedied by using two conductors instead of one, and by so arranging them with reference to the disturbing wires that the currents induced in one of the telephone conductors were exactly equal and opposite to those induced in the other. In this way an induction balance was produced and a quiet circuit secured for telephonic purposes. This method was patented in England in November, 1877, and during the whole winter of 1877-8 I was engaged in London upon experiments relating to the subject.

In the course of these researches I made frequent use of flat spirals of insulated wire, like those employed by the late Prof. Henry** in his experiments upon induction.

My method was to pass a rapidly interrupted voltaic current through one flat spiral while I examined its field of induction by means of another flat spiral connected with a telephone. The currents induced in the latter coil produced a musical tone from the telephone.

At every point in the field of induction it was found that by turning the

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* A Paper (entitled "Upon the Electrical Experiments to determine the Location of the Bullet in the Body of the late President Garfield; and upon a Successful Form of Induction Balance for the Painless Detection of Metallic Masses in the Human Body")—a preliminary notice relating to this Paper was published in the *Comptes Rendus* of the French Academy of Sciences, October 24, 1881—read before the American Association for the Advancement of Science at the Montreal Meeting, August, 1882.

† See Appendix, note 1.

‡ *Pogg. Ann.*, Vol. LIV., pp. 305-335.

§ A similar apparatus was independently devised in America a number of years ago by Professor Rowland, of Johns Hopkins University. It is to be regretted that his discovery of the fact that he had been anticipated by Dove prevented Professor Rowland from completing and publishing his researches.

|| *Phil. Mag.*, July, 1879, Vol. II., p. 50.

¶ *Phil. Trans.* for 1879, p. 417.

** *Silliman's Journal*, XXVIII, 329; XXXVIII, 209; XLI, 117.

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plane of the exploring coil a position of silence could be obtained, and another of maximum sound, the two positions making a right angle with one another.

It was also noticed that when a position of silence was established a piece of metal brought within the field of induction caused the telephone to sound. This effect was most marked when the two flat spirals were in close proximity, and were arranged with their planes parallel, as shown in Fig. 1.

When a silver coin, such as a half-crown or florin, was passed across the face of the two coils, the silence of the telephone was broken three times. The instrument emitted a musical tone when the metallic disc passed the

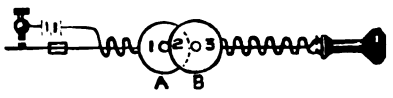

FIG. 1.

points marked 1, 2, and 3 in the illustration, but the loudest effect was produced when the coin crossed the area marked "2," where the two coils overlapped.

After my return to America I embodied these and other results in a paper "Upon New Methods of Exploring the Field of Induction of Flat Spirals," which was read before this association at the Saratoga meeting in August, 1879.

Practical Application.

While brooding over the problem of the detection of the bullet in the body of President Garfield. these experiments made in England returned vividly to my mind. It seemed to me that if the overlapping area "2" of the two coils shown in Fig. 1 could be brought over the seat of the bullet without disturbing the relative positions of the coils, the telephone would probably announce the presence of the bullet by an audible sound.

A crude experiment was at once made to test the idea. A large, single-pole electro-magnet (the core of which was composed of a bundle of fine iron wires) was used in place of coil A (Fig. 1), and a small coil of fine wire taken from a hand telephone was arranged a little to one side of the pole to represent coil B. The small coil being connected with a telephone, a battery current was passed through the coil of the electro-magnet, and the battery circuit was made and broken by an assistant.

Under these circumstances a much better balance was obtained than could possibly have been anticipated. Upon now bringing a leaden bullet near the small coil, a distinct ticking sound could be heard from the telephone each time the battery circuit was made and broken.

Being absent from my laboratory, and without facilities for proper experiment, I communicated my ideas to Mr. Charles Williams, jun., of Boston, manufacturer of electrical and telephonic apparatus, who kindly placed the resources of his large establishment at my service, and at great personal inconvenience delegated his best workmen to attend to my experiments.

Upon attempting to devise an appropriate form of apparatus for the special purpose in view I saw that there were great practical difficulties in the way of utilising the arrangement shown in Fig. 1, and it occurred to me that the apparatus of Professor Hughes might, perhaps, be employed with more advantage as the basis of my experiments. In the ordinary form of Hughes's induction balance four coils are used, as shown in Fig. 2. Through the agency of a Hughes microphone the ticking of a clock is

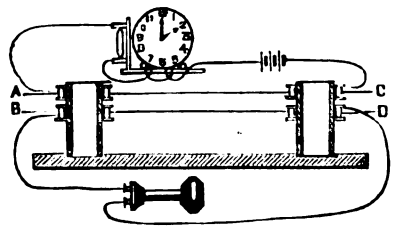

FIG. 2.

made to create an electrical disturbance in the voltaic circuit containing the two primary coils A C, and a corresponding disturbance is produced by induction in the two secondary coils B D connected with the telephone. If the connections are so arranged that the currents induced in the telephone circuit by the coils A C are in the same direction, the ticking of the clock is heard very plainly, but if they are in opposite directions no sound is perceived.

In the latter case the action of one primary coil, A, opposes that of the other, C, and an electrical balance results. If now a piece of metal is brought near one pair of coils (say A B) the balance is disturbed, and the ticking of the clock is audible at the telephone. The arrangement of the coils A, B, C, D was the point to be studied, the microphone attachment being of no importance in the combination; for it is well known that a rheotome to break the primary circuit completely at intervals can be substituted for the microphone with advantage.

It seemed to me that two of the coils A B in the Hughes induction balance might be attached rigidly to a wooden handle, so as to be moved over the seat of the bullet without changing their relative positions, and that all the adjustments necessary might be made on the other pair of coils, which need not be moved from their place, and would not, therefore, be liable to disarrangement. If a single pair of coils were to be used as in Fig 1, they must be adjustable one upon the other. But if during the course of exploration the coil B (Fig. 1) should be moved from its proper position even to the extent only of a small fraction of a millimetre, the balance would be disturbed and the exploration might have to be stopped in order to adjust the apparatus. These considerations led me to the conclusion that some modification of the Hughes induction balance was most suitable for my purpose, and I immediately commenced the construction of such an apparatus.

Suggestions Tested.

Just at this time I learned from the newspapers that Professor Simon Newcomb, of Washington, had the idea of using a magnetic needle to indicate by retardation of its rotation the proximity of the bullet in the body of the President, and I telegraphed to Professor Newcomb the offer of my assistance in carrying on experiments, knowing the comparative difficulty he would experience in having apparatus made in Washington.

At his suggestion I tested the point whether the rotation of a leaden disc and of a leaden bullet underneath a delicately suspended magnetic needle would cause a deflection of the needle.

The disc occasioned a deflection, but the bullet produced no sensible effect. I telegraphed the result to Professor Newcomb, and at the same time took occasion to inform him of the hopeful results I had obtained with the crudely-constructed induction balance referred to above.

I was much gratified by his immediate appreciation of the experiment. He telegraphed that he thought an induction balance promised a much more hopeful solution of the problem than his own method, and encouraged me in every way to continue my experiments.

This appreciation determined me to proceed to my laboratory at Washington, where I was accompanied by Mr. Sumner Tainter, who was anxious to assist in such a cause. I learned from Professor Newcomb that Mr. George M. Hopkins, of Brooklyn, had independently suggested the use of Hughes' induction balance, and had made experiments in Brooklyn, the results of which were published in the *New York Tribune* on the 11th of July, 1881.* Mr. J. Stanley Brown (private secretary of President Garfield) kindly handed to me the letters he had received from Mr. Hopkins,† and also a Hughes induction balance like that shown in Fig. 2, which Mr. Hopkins had forwarded to the Executive Mansion for trial.

This apparatus was at once tested in my laboratory, with results slightly better than those I had obtained in Boston.

My Boston apparatus did not give a greater hearing distance than 3 cm., whereas with the Hopkins apparatus I could distinguish effects at a distance of 3·75 cm.

Two of Mr. Hopkins's coils (A B, Fig. 2) were then fastened upon a wooden handle to form an exploring instrument, and the whole apparatus was arranged for immediate use in case of any necessity arising for an experiment upon the President. I set myself in communication with Mr. Hopkins, and requested his assistance and co-operation, and in reply received through Private Secretary Brown the following account of further experiments:

"60, Irving-place, Brooklyn, July 16, 1881.

"Mr. J. Stanley Brown:

"Dear Sir: I have made two new instruments on plans differing from that sent, but they yield no better results. The first consisted of two oblong coils arranged at right angles to each other, thus:

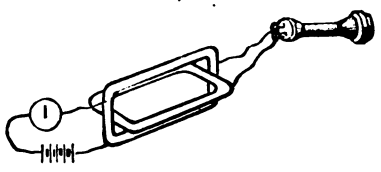

FIG. 3.

"The outer coil being of coarse wire (No. 18) placed in the primary circuit, the inner coil being of very fine wire (No. 36) and connected with a telephone. The parallel currents traversing the wires neutralised each other, and no audible effects are perceived in the telephone, but on presenting a metallic body to the instrument upon a line bisecting the angle between the coils the clicking in the telephone is heard.

"This instrument possesses only one advantage over that sent, and that is that it requires no adjustment.

"The other instrument consists of two large coils of very fine wire (No. 36) placed upon opposite sides of a coil of coarse wire (No. 16), the fine coil being connected so that the induced currents neutralise each other, thus:

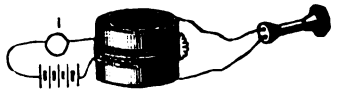

FIG. 4.

"I am sorry to be obliged to say of this as of the other, that it is no more sensitive than the one sent. To produce the best effects from the instrument which you have it will be necessary to use all the battery power possible without burning the coils, and two receiving telephones of the best construction must be used.

"As I stated in the first instance, if the ball is more than two inches deep, I think it cannot be located by this means.

"If larger coils were used the instrument might be operative at a greater distance, but the area indicated as containing the ball would be so large that the result would be indefinite and without value.

"Hoping that Professor Bell will be able to succeed, I remain,

"Yours very truly, "Geo. M. Hopkins."

Professor Hughes, of London, England, Professor Trowbridge, of Harvard College, Professor Rowland, of Johns Hopkins University, and other authorities were consulted by telegraph as to the best theoretical form of induction balance for the purpose required, while empirical experiments were being carried on under my direction in my laboratory at Washington by Mr. Sumner Tainter: in the electrical workshop of Davis and Watts, in Baltimore, by Mr. J. H. C. Watts, and in the establishment of Mr. Chas. Williams, jun., in Boston, by Mr. Thomas A. Gleason. To test the influence of size of coil an instrument was constructed in which the coils were no larger than the bullet for which we sought (as had been suggested

* See Appendix, note 2.

† See Appendix, notes 3 and 4.

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by Professor Newcomb),* and experiments were also made with the enormous coils used by the late Professor Henry in his researches upon induction, which were kindly lent to me for the purpose by the Smithsonian Institution, but neither the small nor the large coils produced more satisfactory results than those we had already obtained.

To test battery power, 20 enormous Bunsen elements, which had formerly been used to light the gas at the Capitol, were placed at my disposal by Mr. Rogers, electrician of the Capitol, but while great electromotive force was evidently of use we derived no advantage from such a battery as this.

To test the influence of speed of interruption, Mr. Marean, superintendent of the Western Union Telegraph Company in Washington, kindly lent us an electric motor, by means of which we were able, with the aid of a rotating commutator, to obtain interruptions of the primary circuit of all rates up to 600 interruptions per second†, and we found that the more

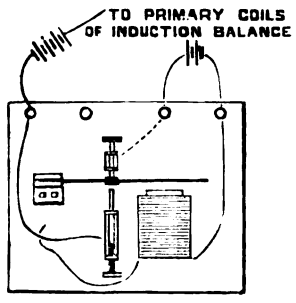

FIG. 5.

rapid the rate of interruption the more distinct was the sound in the telephone. The hearing distance, however, was not proportionately increased. The automatic interrupter, (shown in Fig. 5,) yielding about 100 interruptions per second, gave as good results as any, and was much more convenient. This interrupter was therefore afterwards used exclusively in our experiments.

The theoretical form of coil suggested by Professor John Trowbridge ‡

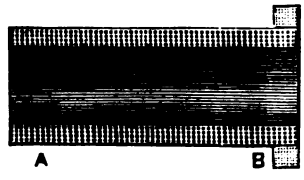

FIG. 6.

was substantially the same as that proposed by Professor Rowland§, and is shown in Fig. 6

The arrangement was quite sensitive to metal placed in the interior of the coil, but the hearing distance for a bullet external to the coils was no greater than before.‖

Professor Hughes¶ proposed to have two flat superposed coils wound on a single reel, so that the two coils should form a single one as regards their relative distance; and Mr. F. T. Bickford, Washington correspondent of the *New York Tribune*, suggested winding two wires side by side into a single coil, so that the relative distances of the wires from the bullet should be absolutely the same. Mr. Charles E. Buell** and Dr. Chichester A. Bell†† proposed to determine the depth of the bullet beneath the surface by causing a similar bullet to approach the balancing coils until silence was restored; the secondary bullet, it was presumed, would then be at the same distance from the balancing coils as the embedded bullet from the exploring coils.

The results of all the experiments so far made were unsatisfactory. I had tried everything that had been suggested, but 4 cm. remained the extreme limit of audibility for a bullet like that which had struck the President. Even when such a bullet was flattened by being fired against a board, and was presented with its flat side towards the coils of the explorer—the most favourable mode of presentation—no better result was obtained.

Original Experiments.

In the theoretical arrangement recommended by Professors Trowbridge and Rowland (Fig. 6) the primary coil A was of smaller diameter than the secondary B. This had given us no better effects than the ordinary form of Hughes balance (see Fig. 2), in which the two coils A B were of equal diameter. We then tried the effect of making the primary coil A of greater diameter than the secondary B (see Fig. 7); and in this case we appeared to obtain an increase of hearing distance. Five centimetres (two inches) was, however, the utmost limit reached when, on the 19th of July, Mr. J. Stanley Brown and Dr. Woodward visited my laboratory and witnessed some experiments. No difficulty was experienced in detecting a bullet held in the mouth by passing the exploring coil over the cheek: and the presence of a flattened bullet held in the clenched hand was also readily determined. Dr. Bliss, Dr. Reyburn, and Surgeon-General Barnes visited the laboratory next day, and expressed themselves as very hopefully impressed

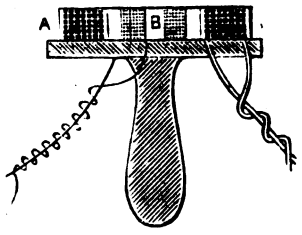

FIG. 7.

by the experiments. These were subsequently repeated in the surgeon's room at the Executive Mansion for the information of Dr. Frank Hamilton and Dr. Agnew, who also seemed favourably impressed.

Such opinions from the surgeons in attendance upon the President, and the continued interest shown by Professor Newcomb, encouraged me to proceed with the experiments.*

It was now determined to test the effect of each convolution of the primary coil, so as to arrive empirically at some idea of the best shape of coil. For this purpose Mr. Tainter constructed the instrument shown in Fig. 8. Circular grooves were turned in two boards, one of which is

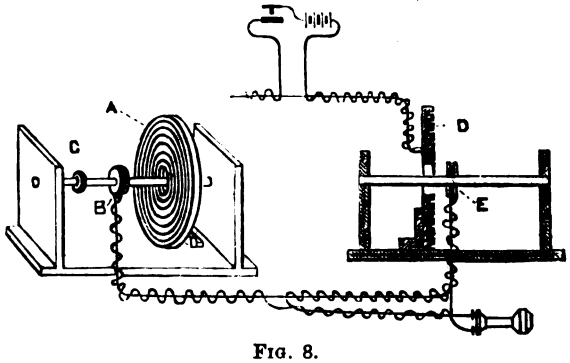

FIG. 8.

shown in perspective at A, and the other in section at D. An insulated copper wire could be pressed into any of these grooves so as to give the wire an exactly circular shape of known diameter, and the two ends were passed through an orifice in the back of the board, making connection with a similar ring of wire in the other instrument, as shown. A small secondary coil B of fine wire, which could be moved with moderate friction upon the horizontal rod, was connected to another similar coil E, and to a telephone; and a small brass ring, C, which could also be moved along the horizontal rod, was used instead of a bullet to disturb the balance.

In making an experiment with this apparatus the secondary coil B was first placed within the primary ring and in the same plane with it, and the balancing coil E was adjusted to produce silence. The brass ring C was then moved along the horizontal rod until the balance was sensibly disturbed and the relative distances of the coils and the brass ring were noted.

(TO BE CONTINUED.)

THE FAURE ELECTRIC ACCUMULATOR COMPANY.

An extraordinary general meeting of the shareholders of this Company was held at the Cannon-street Hotel on Monday last, Sir A. J. Otway, Bart., M.P., in the chair.

The SECRETARY (Mr. Herbert Canning), having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen, you have heard the notice read convening this meeting, which I need scarcely say is one of considerable importance to all of you who are interested in the Faure Company. Now, certain contracts have been provisionally signed by the Board of the Faure Company. I say provisionally, because those contracts have no validity whatever until you should ratify and approve them. On your approval and ratification they will become good and valid contracts, but not till then. These contracts have been drawn in pursuance of the policy indicated in a speech made to you by M. Philippart, which was rendered into English on two occasions—a very clear statement, I must say—and to which policy you on two occasions gave your adhesion. On the second occasion I felt bound to tell you that the Board, not concurring in the proposed procedure, would not be able to continue their functions as administrators of the Company, and that they would ask to be relieved from the office they now hold, and that others should be put in their places. They also thought that those appointed to fill their places should be gentlemen who were in entire accord with M. Philippart in the policy he was about to carry out, and as the working of the Company would henceforth be carried out in France,

* See Appendix, note 5.

† Mr. Sumner Tainter has since made an apparatus operating in a similar manner, by means of which he has obtained as many as 4,000 interruptions of the circuit per second.

‡ See Appendix, note 6. § See Appendix, note 7.

‖ The balance obtained was not quite perfect, and we have since discovered that the insulation of the wires of one of the secondary coils was defective.

¶ See Appendix, note 8. ** See Appendix, note 9. †† See Appendix, note 10.

* I desire specially to express my gratitude to Dr. Frank Hamilton for words of encouragement spoken at a later date, when sympathy and encouragement were greatly needed.

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and not in England, I thought that they should be rather French than English directors. Well, now, M. Philippart, after the meeting, entered into certain arrangements with which I have no concern. He will have an opportunity of addressing you, and I am perfectly certain that he will explain what he has to say in a clear manner to you. He entered into certain arrangements, which were limited, as he informed us, as to time. The consequence was that, unless those arrangements were to fall through entirely, and the prospects which appeared to M. Philippart so bright were to be dispelled, it was necessary that those agreements should be signed provisionally by the Board. Hence, that which may appear an inconsistency, but which is not so in point of fact, is perhaps to be found on the part of some of you who hear me, namely, that the signature of some of the members of the Board is given to contracts of which they do not themselves approve. But that was done because time was the essence of this matter, and under the condition that they should be entirely of a provisional character. Now, I am not here to express an opinion on the contracts themselves. They will be read by our solicitor, a most able and experienced gentleman, and M. Philippart will address you also. Nor am I about to enlarge on the feeling of the Board in regard to them. They are matters upon which gentlemen very often differ. A mode of carrying on business may commend itself to some gentlemen that is not so well thought of by others. I may also remind you again of the reason I gave you on the last occasion on which we met that the mere fact of the business being transferred to France, to my mind is quite sufficient to relieve us of the position of being useless in London. It is not a position that would suit any of my colleagues or myself to fill a useless purpose, and the operations of the Company being transferred to France, that would be the result if we retained our positions. That being so, it is unnecessary for me to enlarge on the precedure, and our absence of concurrence therein. There was one condition I thought only essential to make, and I adverted to it on the last occasion. I said I would not leave my place at the Board till I was certain that that which I considered a sort of honourable engagement we had taken towards the shareholders had been fulfilled, or unless means had been provided by which it should be and must be fulfilled. I understand from our solicitor that those means are now provided. I allude to the question of supplying every shareholder who has applied for the same with one fully paid up share in regard to two of his present shares with £2 paid thereon. A certificate will be lodged embracing the aggregate number of shares. It has not been possible to divide these shares at the present moment so as to give to every shareholder his one share fully paid up for the two he holds, but a certificate of the aggregate amount necessary to do that will be consigned to the custody of Mr. Campbell, the solicitor, and myself if you like it, as trustees for the carrying out of this operation, and I understand that at the latest, on the 2nd day of January, M. Philippart will be prepared with all the certificates then divisible among the shareholders who apply for them. Certain formalities will be gone through. A letter will be sent to every shareholder. I understand that this is the process—that it will be intimated to him how he is to apply for his certificate, and thereupon one fully paid up share will be given to him in exchange for every two he now holds. When that is done, all I can say is that I shall consider that our business as administrators terminates. I must say that we have had as little agreeable and as anxious a time as it was possible for any gentlemen to have. We have had a great many difficulties to contend with. It is not very pleasant for gentlemen who pursue a business on one line to be suddenly called on to pursue it on other lines. I am not at all ashamed of the operations we have carried on. I think they redound very much to the credit of the Faure Company, and have tended very much to popularise the accumulators in this town, and I can only think that the future of the accumulator will be very great. I cannot help regretting that it will not be in England that its great success will be achieved; but there are conditions, no doubt, more favourable for the accumulator in France than in this country. They will suggest themselves to you probably, such as the price of coal, the consumption of gas, and the price of gas, and those conditions make it more profitable in France than in this country; that, however, is not our concern. We intended to be an accumulator company—an industrial company. That was our wish. By the decision of the shareholders that is altered, and the business is transferred to another country. Our services are rendered useless, and we now seek our right to retire from our places at the moment we can. I am not aware that that cannot take place almost immediately. We cannot leave the Company utterly without any one. We have one director who will remain. M. Philippart will remain on the Board, and it will be necessary to nominate some other director. These two gentlemen forming a quorum will be able, I hope, to find some satisfactory colleagues to carry on the business of the Company. I shall be very glad, as this will be the last occasion we shall have of meeting you (at least on this side of the table), if any gentleman present will interrogate us on any matter on which he may desire information, because we should like to have the opportunity of answering him. We are in this fortunate position at least. We have nothing to conceal, and we should like to have this opportunity of answering any gentleman's questions concerning the Company, or the way it has been carried on; and we should like to hear any remarks that they may have to make. I shall now ask Mr. Campbell, the solicitor, to read to you those agreements, and explain them, and then M. Philippart will inform you how he intends to carry them out, and what view he takes of the future prospects of the Company. Mr. Campbell will now read first M. Philippart's statement, and then you will hear the agreements read.

Mr. CAMPBELL (the Company's solicitor): This is a sort of prelude to the agreement, and I think the agreements will be more easily understood. This is M. Philippart's statement:—Gentlemen, the contracts which are to-day submitted for your approval were only signed on Thursday last. In my opinion they might and ought to have been signed sooner, and without the reservation of your approval, for they only carry out the programme which you unanimously approved on the 6th November last, and the particulars of which you received with enthusiasm at our meeting on the 4th of this month. I cannot now enter into all the details of these contracts, for it would take up too much time, and would, besides, be unwise in our common interest, but I wish again to touch upon their salient points in order that you may seize the advantage we shall derive therefrom. By the first of these contracts the Storage Company returns to you your 20,000 fully paid up ordinary shares, which were allotted to them by the agreement of the 6th and 7th of July last, and the Société la Force et la Lumière surrender as well the 50,000 deferred shares. On the other hand we cede to the Storage Company definitely and entirely the interest which we retained in the Faure, Sellon, and Volckmar patents for the United Kingdom. By the second and third contracts our Company obtain possession of about 92 per cent. of the Faure-Sellon and Volckmar patents for France and the French colonies. In virtue of those contracts this interest will be represented by preference and ordinary shares of the French Electrical Power Storage Company, which company possesses the exclusive right to the exploitation of those patents. Our intention is to sell some of these shares, and to employ the proceeds of those sales in the purchase of the Faure-Sellon and Volckmar patents for other portions of the Continent, reserving the balance either to be distributed to you in whole or in part as dividends, or to be retained by our Company, as may be deemed most advantageous for you. After the fulfilment of these contracts, and when the 40,000 ordinary shares of our Company are fully paid up, the following will be our financial position: Of the 80,000 ordinary shares of our Company 47,000 only will be issued, 33,000 unissued. Our assets will consist, as I have already told you, of an interest representing about 92 per cent. of the Faure, Sellon, and Volckmar patents for France and the French colonies and we shall, further, have available a sum exceeding £100,000. I trust you will be pleased to learn that after the execution of these contracts we expect to be able to pay in the course of the month of January next a dividend at the rate of 10 per cent. per annum from the date of issue upon the £2 paid of our 40,000 ordinary shares. Let me add that I have cogent reasons for stating that during the month of February next we shall be able to declare a further dividend of at least £4 a share, and that I hope for still greater things. It is, of course, understood, gentlemen, that the execution of these contracts assures the fulfilment on the due date of the engagement taken by the Société la Force et la Lumière with those among you who have accepted this offer. Your chairman and his colleagues deemed it right to retain their seats till this engagement was fulfilled. I have no wish to underrate in your eyes the services of my colleagues, but I do wish to take this opportunity of stating that the Société la Force et la Lumière never had any idea of departing from this undertaking; but that, on the contrary, it was well pleased that so many of you accepted its proposal, and that it is of opinion that it has done a good business which it would on no account relinquish. Even were this not the case I have the right to say on my own behalf and on that of my friends that your interests will be as well looked after by us as by others. Certainly we are not infallible, and we may make mistakes, but you have, at any rate, the guarantee that should we do so we shall ourselves be by far the greatest sufferers. Allow me once again to touch on the value of the patents we possess, and enter into a few details in connection therewith. On the 6th of November last I said to you—1st, that the accumulator was as great a necessity for electricity as was the gasometer for gas; 2nd, that the Faure Sellon and Volckmar accumulator was so far the only practical and economical accumulator; 3rd, that we had the best reasons for believing that it would not be superseded. I do not believe, gentlemen, that any one will even now attempt to controvert the two first assertions, and, in support, thereof, I am pleased to be able to tell you that the company, which had purchased the Donnithorne accumulator, of which we had heard so much, has entirely abandoned it, and has applied to the Storage Company to furnish it with all the accumulators it requires. Indeed, the Storage Company cannot nearly execute all the orders it receives, although producing 250 tons of accumulators monthly. As to the third, it will be said that no one can put a limit on the progress of science. The whole question to be solved is the extent of progress which is required to attain perfection, and consequently the nearer we attain perfection the less room will there be for improvement, and, therefore, the less we shall have to fear. To arrive at the relative value of an invention three things have to be considered. First, prime cost; second, the cost of maintenance; third, yield. Now what progress still remains to be made under these heads? Prime cost: Our accumulators are now made exclusively of plates of lead, cast with holes in them, in which holes we place red lead or oxide of lead. These plates, after having been formed by the passage of an electric current, lasting 100 or more hours, are placed in a wooden box lined with sheet lead, and separated from each other by india rubber bands. The first cost of the material is from £15 to £16 a ton, and that of the labour about an equal amount. What can be discovered simpler or more economical? Maintenance: Half the plates composing an accumulator are called positive and half negative. Experience proves that the negative plates do not wear out in working. The positive plates only, after a greater or less number of months' work, become unfit for working, owing to the entire peroxidation of the plates. Thus the maintenance of the batteries renders the replacing of half of the plates necessary every year on a most liberal estimate. But this replacing simply entails a question of labour, seeing that it is only necessary to grind up these peroxidised plates, and with this ground peroxide to fill up the holes in the new lead plates, unless indeed, which is probable, this peroxide is sold at a much higher price than the lead or red lead, in which case the maintenance of the accumulator will become a source of profit instead of a source of loss. It is clear, therefore, that both from the point of view of cost of maintenance and from the point of view of prime cost, there is little room for improvement. Yield: Eighteen months ago Sir W. Thomson certified that the first Faure batteries which were subjected to experiments by him gave a yield exceeding 75 per cent. Six months later our eminent electrical engineers, Messrs. Ayrton and Perry, certified a yield of over 80 per cent., and I am satisfied that to-day, with the good system of charging and discharging, we can attain a yield exceeding 85 per cent. Such being the case, am I not justified in telling you, gentlemen, that we need not fear more from the future than from the past?—that the progress we have made during the late 12 months is a guarantee of that which we shall continue to make? Further, I do not lose sight of the fact that any improvements made by others will belong to us, and will remain useless in the hands of the inventor so long as our patents are in force. You see, gentlemen, therefore, on what a solid basis our confidence in the future of our Company is founded.

Mr. CAMPBELL, after the reading of the foregoing statement, went on to describe the effect of the three agreements.

The CHAIRMAN: It would be interesting to the meeting that Professors Ayrton and Perry should make some observations to you on some technical points with regard to the result of certain experiments they made last

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Saturday with the Faure-Sellon-Volckmar accumulator at the Storage Company's works.

Professor AYRTON: I must preface the few remarks I am going to make on behalf of Professor Perry and myself by saying that they do not relate to this Company's commercial or financial aspect, with which indeed we are not concerned, but they merely relate to the accumulator as viewed from an engineering point of view. It must be clear to all of you that in order that success may be attained in any invention the first point that is necessary is that there shall be a good idea to work on as a basis, the second that you stick to the improvements and developments of your idea until it bears good fruit. That the Faure invention is most valuable cannot be doubted by any one, and that both at the Electrical Company's works at Millwall, as well as at the works of our own company at Paris, a vast amount of energy and enterprise has been spent in improving the accumulator is also equally clear to all who have had an opportunity, like ourselves, of seeing what has been done. The Faure accumulator, as originally made, had three defects, first, that, great as was the advance it constituted on the Planté cell, still its capacity for storing electric power was not so very large; secondly, the rate at which this power could be taken out of it was limited; and, lastly, some kind of flannel or felt was employed to keep the red lead in contact with the lead plates and prevent the plates touching one another. In all these three directions the cell has been immensely improved during the last twelve months, so that whereas we thought it an excellent result to find last December that a cell weighing, with the lead, red lead, acid, and box, about 130lb. contained electric energy equivalent to one horse-power for three-quarters of an hour, our recent tests of the Faure-Sellon-Volckmar cells show that in a gross weight of only about 75lb., consisting of lead, oxide, acid, and box, there is a store of one horse-power for one hour; further, that whereas, in December last, we regarded a steady discharge without polarisation of a third of an ampere per pound gross weight a good result, we now can obtain as much as three-quarters of an ampere per pound gross weight. Altogether, then, the electrical value of the accumulator of the end of this year is double that of a good accumulator at the end of last. If an accumulator be regarded as a kind of coal cellar, then to maintain the analogy not only must it be considered that twice as much coal can, so to say, be now stored in a cellar of fixed size as could be stored last year, but the cellar door for a particular cellar has been made twice as wide, so that the coal can be got out of the cellar much faster, and consequently much larger fires kept burning. In addition, the flannel or felt in the accumulator is now absent, so that the positive and negative plates in the box are quite distinct, they are not only "*formed*" quite separately before being put into the box, but they can be separately taken out of a complete cell and examined, and an inferior plate, if there be one, easily removed and a good one put in its place. Indeed, it is due to these great advances in the construction of accumulators that an electric boat has been able to perform regularly its successful trips on the Thames, which we, like others, have had the pleasure of witnessing. And, again, it is this more rapid discharging power of the latest form of accumulators that has enabled us successfully to employ our electro-motor to drive a tricycle, which, when weighted with one man and sufficient accumulators to store two hours' driving power, runs over a measured mile in 8¾ minutes, whereas six months ago a slow walk was all that we could accomplish. As regards, then, facility in construction and repairs, in largely increased storing capacity and rapidity of discharging power of accumulators, this year has seen a great advance.

The CHAIRMAN said they would be glad to hear any remarks from any shareholder, and to give any explanation they could with respect to the agreements.

A SHAREHOLDER: A question suggested to me is whether the law in France is more favourable than it is in this country as to locomotives.

Professor AYRTON: The use of the word "locomotive" is a misnomer. An electrical tricycle is not a locomotive, and it is a question whether it would come under the Act. I was yesterday consulting with the counsel who opposed the steam tricycle, and he told me he thought as the Act was only for a little time, and had to be renewed from time to time, that there would be very little difficulty in getting permission for electrical tricycles but not steam tricycles.

The CHAIRMAN: We cannot give you the information about the law in France. I think it is very much the same as in this country. If no one wishes any information we will put the agreement for your ratification.

A SHAREHOLDER: When we met at the first meeting to inaugurate this new policy the tone of your speech was eminently favourable to what has been adopted. It influenced the meeting very much, and I should like to put the question now, whether anything has transpired at all to alter your opinion of the character and the result of those negotiations and agreements.

The CHAIRMAN: That is a very fair question, and I shall consider it my duty to answer it. I am not aware how far the tone I took was of the character you ascribe to it, but I am perfectly certain of this, I had no desire whatever to say anything unfavourable as to the policy of M. Philippart in its general terms. Nor do I now wish to say a word unfavourable to it. Where I have been unable to concur with him is in the procedure by which he is proposing to carry out the policy. I have never been mixed up, as I have said, in my life, and I never intend to be, in any financial business, and all these various companies are not matters with which I choose to be concerned, but I have the most entire confidence in M. Philippart. I have always said that, and I do not depart from it, and this matter in his hands in France I sincerely hope will be productive of benefit to you, but it is not a matter in which I chose to be concerned.

After a few more remarks from the Chairman,

Sir CHAS. CLIFFORD said that at one time the Board thought they were going to develop the accumulator which was in their hands, and they believed it was to be productive of wonderful events in the world, but at last they found that the largest proportion of the shares (he thought two-thirds) had got into the hands of one individual and his particular friends, and when they inquired into this they found that the command, which by these means M. Philippart and his friends obtained over the Company had quite prevented, or would naturally prevent, the Board from carrying out their schemes. Moreover, those schemes were to be identified with French interests, not with English interests, and were not so much intended for the development in the Board itself of the wonderful powers of the accumulator, but were to use the accumulator for financial purposes, whereby M. Philippart would probably gain a better dividend for the shareholders, but which left to others the development of the principle. Looking to all these things, the Board came to the unanimous determination that though they were extremely pleased to work for the benefit of the shareholders and for the benefit of science, they did not think they were justified in working for the benefit of a small party, and came to the conclusion, if they could do so without injuring their interests, to resign their positions into the hands of others who knew more about the schemes likely to be introduced than they did themselves. The consequence of that determination was this meeting. He had no doubt M. Philippart was quite able to carry out the schemes he had explained. He might also say that M. Philippart and his friends were quite right in acting as they had done, believing as they did that the interest of the shareholders was very much served by the schemes they were intending to adopt. The shareholders, however, must remember that now at this meeting the Board were resigning into their hands the trust that had been reposed in them, and they resigned that trust into the hands of others over whom they should have no control. They had heard of the pleasant prospects that were before them. He hoped those prospects would be realised, but let them bear in mind not to reflect on the late directors, but to lay all the blame and award all the praise to the directors that were to follow. Let the present Board go away with a clean sheet in the favour of the shareholders, and he was satisfied.

A SHAREHOLDER wished to ask whether, in the event of the hopes held out being realised, and these large dividends being paid, those who did not consent to the conversion of their shares would be equally entitled to participation.

The CHAIRMAN: Oh, certainly, you will be rewarded by your courage.

M. PHILIPPART having addressed a few remarks to the meeting in French,

Mr. CAMPBELL interpreted them as follows:—I wish to make a very few observations in reply to what the chairman has said. It is entirely a mistake if you think we are going to enter into questions of finance, if by finance you mean a speculation. From the report read to you and the explanation of Professor Ayrton you must see that your profit must come from the use of the accumulator and the development of the accumulator, and not from speculation. I wish you to understand it is our simple intention to proceed with this matter as an industrial scheme, and only as an industrial scheme.

A SHAREHOLDER: But when we first met on this matter it was to cease to be an industrial scheme, and to be a purely financial scheme of bringing out companies and selling concessions.

M. PHILIPPART having again addressed the meeting,

Mr. CAMPBELL (interpreting) said: In speaking of it as an industrial company I point to the great extent of France, and this Company will be the owner of shares in the company which holds the accumulator for the whole of France, for which it will have the rights and privilege of manufacturing accumulators. But to supply France it wants companies in the towns who will take licenses from that Company and carry on the system of electricity in the different towns. The mother company will provide the accumulators as they may be required. In answer to another question, he said that the whole of the companies they were assisting would be limited companies, and the Faure Company would hold shares representing 92 per cent. of the mother company in France, which was a company formed under English law.

A SHAREHOLDER wished to ask whether any litigation was going on against the present directors, or those who were about to resign.

The CHAIRMAN: I was threatened with proceedings, I must say, but such matters do not alarm me much, as they generally come from those who wish to get something from you. A firm was of opinion that we had entered into contracts with them that we had not carried out. We had a different opinion on the subject. The result has been, whatever differences there were, that all proceedings, if any were seriously intended, have been abandoned. There is no concealment in the matter. We had ordered a certain number of those accumulators, and those accumulators had not been taken. There was some question whether they were quite up to what we expected, but now they will be taken as they are supposed to be good, and I hope that they will turn out well and an amount will be paid according to the agreed contract price.

A SHAREHOLDER: It appears by these contracts, if they are ratified, that the Faure Company transfer their entire business in England to the Electrical Storage Company formed in France. The Faure Company becomes French and the Storage Company English. At the last meeting the question of an extension (but not the substitution of another company) came up. Now it is an entire change of the Faure Company.

A SHAREHOLDER: If it becomes a French company what will be its status in England? Will the meetings be held in England?

Mr. CAMPBELL (the solicitor): You are an English company and remain so, and you draw your profits out of this Company in France.

A SHAREHOLDER: Will all explanations be given in England as hitherto?

Mr. CAMPBELL: Certainly.

A SHAREHOLDER: Then I suppose the new Board meetings will be in France?

Mr. CAMPBELL: The Board will always meet in England exactly as now.

The CHAIRMAN: I think we must now put the resolutions.

Mr. CAMPBELL: Then it is simply turning the notice into the resolution:—

Resolved, "That the agreement between the Faure Electric Accumulator Company (Limited), of the one part, and the Electrical Power Storage Company (Limited), of the other part, for the sale by the Faure Company to the said Storage Company of the remaining interest of the Faure Company in the patents of Faure, Sellon, and Volckmar in England, on the terms and conditions mentioned in the said agreement, and now read to the meeting; also that the agreement between the Société la Force et la Lumière, of the one part, and the Faure Electric Accumulator Company (Limited), of the other part, for the purchase by the Faure Company of the rights and interests of the Société la Force et la Lumière in the French Electrical Power Storage Company (Limited), on the terms contained in the said agreement, and now read to the meeting; and also the agreement

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between the Faure Electric Accumulator Company (Limited), of the one part, and the French Electrical Power Storage Company (Limited), of the other part, for the sale by the Faure Company to the said French Company of the property in Paris belonging to the Faure Company, and providing for the Faure Company subscribing for shares in the said French Company, as provided in the said agreement, and now read to the meeting, be approved by the meeting, and that the directors be authorised by this meeting to complete and carry the same into effect."

The CHAIRMAN: I consider I have discharged my ministerial duty. I believe there are many gentlemen who approve the resolution, and I will ask some gentleman to be kind enough to propose that it be ratified.

Mr. CUSTANCE: I will move it.

Mr. GOLDEN: I will second it.

The CHAIRMAN: I am about to put this resolution. You have heard all the explanations—all, I think, that can be said on the subject—and questions have been asked and answered. I shall say no more than this, that the entire responsibility rests with you. What I hope is that it will be thoroughly successful. If you ratify this, as no doubt you will, these contracts become valid. Sir Charles Clifford has pointed out with great clearness (I do not wish to controvert any statement that we have heard) that we are not responsible for any of those statements. They come from other parties, and not from us. Mr. Custance has moved, and Mr. Golden has seconded, the proposition as read by Mr. Campbell be now adopted, by which you will ratify these various contracts.

After being put to the meeting the resolutions were declared unanimously adopted,

The CHAIRMAN remarking: Therefore there follows the ratification of the various contracts. Replying to a question, he added M. Philippart remains a member of the Board. The English directors intend, as soon as we can, to resign. We have one vacancy by our Articles of Association, and to facilitate your operations we think it right to do what we can to give effect to that which has been for the third time assented to, and we propose to nominate the French director, of whom satisfactory references will be given. You will hardly expect that I, or my colleagues, would accept any one of whom we knew nothing, and put him on the Board, having charge of all your concerns. We shall require some references as to the gentleman, and if they are satisfactory we shall nominate him to the vacant place now on the Board. He will then, with M. Philippart, who will remain on the Board, have power, two forming a quorum, to fill up the remaining vacancies. If they think it right to appeal to the body of the shareholders to determine, that will be for them, not for us.

M. PHILIPPART again addressed the meeting in French, his observations being interpreted by Mr. Campbell as follows:—In the month of February you will be called together to approve the names of the directors whom it is proposed shall follow the present Board.

A SHAREHOLDER asked if there was no hope of inducing the present Board to accept seats.

The CHAIRMAN was afraid not. In reply to a further question, he said he held as many shares as he always held, but all he hoped was that he had secured by the scheme a very satisfactory exchange.

Sir CHARLES CLIFFORD said all the directors had acted exactly in the same way.

A SHAREHOLDER: Have you transferred your interest in the new company?

The CHAIRMAN: I do not understand you.

The SHAREHOLDER: I gathered from the first meeting that your interest would be transferred.

The CHAIRMAN: I took originally one hundred shares. I hold those one hundred shares. I have no intention to part with my interest in the company, but I have accepted the arrangement by which fifty fully paid-up shares are offered me in exchange for a hundred with £2 paid. There is no more business before us.

Mr. STAPLES moved, and Mr. TURNER seconded, a vote of thanks to the Board of Directors, the Chairman, and M. Philippart, which was cordially agreed to.

The CHAIRMAN in reply said: As this is the last occasion we shall meet, I beg to thank you very sincerely for the vote which you have just passed. The gentleman who proposed this vote said no more than the truth when he stated that we had had considerable difficulties. I have found myself for some months past in the most difficult position I have held in my life in reconciling the great conflict of ideas. But I do believe every one has wished to do what he considered best for the Company. M. Philippart has a very large interest, and has always said that no one has so large an interest as he has in the prosperity of the Company. I may add that I have been surrounded by very able colleagues, men who have always given me their support on every occasion, and therefore we have been able to get out of our difficulties without any greater disturbance than was absolutely necessary. I join with you now in trusting sincerely that all the bright prospects held out will be realised, and if so you will owe M. Philippart a deep debt of gratitude. I consider then that he will have done great things for the Company.

M. PHILIPPART said: The only way I can thank you is to earn for you the dividends I have promised you.

The meeting then closed.

DR. SIEMENS ON TECHNICAL EDUCATION.—The annual meeting for the distribution of prizes and certificates in connection with the Institute for the Advancement of Technical Education was held this week in the hall of the Goldsmiths' Company, Foster-lane. After the presentation of the prizes, Dr. Siemens said that Sir Frederick Bramwell had prevailed upon him to present the prizes on this occasion, and had urged that he was a fit person to do so. The distinction made between ordinary and honour prizes, marking the addition of some scientific knowledge to proficiency in applied science, was worth the attention of all students. It was not sufficient for after-life to be efficient in a craft or calling. Unless the workman also mastered entirely the scientific principles underlying that calling, he might, in consequence of some invention changing the *modus operandi* in an occupation, be left high and dry, whereas with a knowledge of fundamental principles he could adapt himself to changed circumstances.

GAS EXPLOSION.

About half-past four in the afternoon of Saturday last passers-by in the Strand, in the vicinity of Charing-cross Station, were startled by a loud explosion and crashing of glass. A large crowd gathered about the shop of Mr. John Chandler, who occupies one of the small box-like compartments between the gateways leading to the station, as a cigar shop. Gas was employed for both lighting and heating, and by some unknown cause a large amount had leaked from the pipe which is laid under the floor, and, the latter being covered with linoleum, a quantity of gas had accumulated. This being ignited by the gas jets above, a terrific explosion followed, tearing a large hole in the floor, blowing out the rear and inside front window glass, and scattering the goods about promiscuously. A large case was thrown into the yard outside, and two of the feet of the gas stove—which was not in use at the time—were carried by the force of the explosion into the railway station. The sole occupant of the shop at the time was a young man, who was behind the counter when the accident occurred, and narrowly escaped being killed. He was, however, only slightly scratched by the counter being thrown over on him. Had there been any customers in the shop at the time they must have, by reason of the smallness of the place, been standing immediately over the spot where the explosion occurred, and nothing short of a miracle could have saved them from being killed. Gas may be cheap, but it is sometimes nasty as well.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES DEC. 20.		BUSINESS DONE WEEK ENDING DEC. 20. Highest.	Lowest.
Anglo-American	48,	49	47½	47½
Do. Preferred	79,	80	79½	78½
Do. Deferred	18,	19	17½	17½
Brazil Submarine	11⅞,	12	12	11⅞
Cuba	9½,	10	—	—
Do. Preference	16,	17	—	—
Direct Spanish	6½,	7	—	—
Do. Preference	16,	17	—	—
Direct United States Cable	11⅜,	11½	11 9-16	11 7-1
Eastern Telegraph	10⅞,	11⅛	11⅛	10⅞
Do. 6 per Cent. Preference	13½,	13⅝	13⅝	13½
Do. 5 per Cent. Debentures, 1899	103,	106	—	—
Eastern Extension	11⅞,	12⅛	12⅛	11 15-16
German Union	10,	10½	10½	10½
Globe Telegraph and Trust Company.	6½,	6⅝	6½	6 15-16
Do. Preference	12⅜,	13	12⅝	12 11-16
Great Northern	12½,	12⅝	12 11-16	12⅝
Indo-European	31,	32	—	—
Mediterranean Extension	1½,	2	1⅞	1⅝
Do. Preference	6,	8	—	—
Reuter's	12½,	12⅝	—	—
Submarine	250,	255	250	255
West India and Panama	1½,	1⅝	1 7-16	1 7-16
Do. 1st Preference	7,	7½	7½	7½
Western Brazilian	7⅞,	8⅛	8 1-16	7 13-16
West. Union 7 per Cent. 1st Mortgage	122,	128	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¼	13-16	⅛
Oriental	⅛,	¼	13-16	⅛
United Telephone	10½,	11	10½	10⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	6⅛,	6⅞	8	6⅞
Do. (fully paid)	11,	14	16½	12½
Hammond Light	3½,	4	4⅛	3 11-16
Eastern Electric	1⅛,	1⅜	2	1⅜
Pilsen, Joel, and General Electric	1,	1⅛	—	—
Gülcher (£1 10s. paid)	—,	—	—	—
Swan	1⅞,	2	2	1⅞
Maxim-Weston	⅜,	½	½	⅜

TRAFFIC RECEIPTS FOR NOVEMBER, 1882.

COMPANIES.	Nov., 1882.	Nov., 1881.	Incrse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	1,800	2,439	—	639
Direct Spanish Telegraph Company	—	—	—	—
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	54,098	49,829	4,269	—
Great Northern Telegraph Company	20,440	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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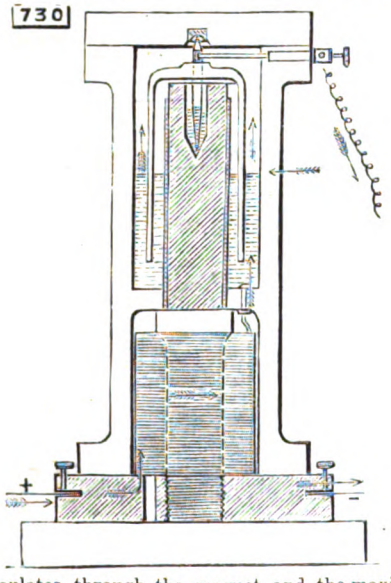
RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

730. Improvements in Apparatus for Measuring and Registering Electric Currents, *C. A. Faure, Strand, London.*—15*th February*. 6*d*.

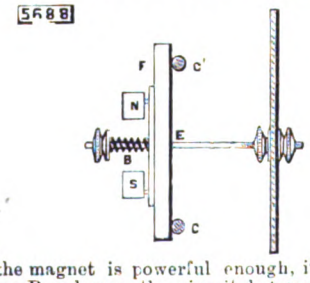
The principle of the invention is that a conductor conveying a current tends to rotate round a magnet. The apparatus is illustrated in the accompanying figure. A cylindrical electro-magnet is mounted vertically within a vessel containing mercury. A conductor in form like the flier of a spinning machine is pivoted on the top of the magnet core, and its arms dip down into the mercury. The current to be measured



circulates through the magnet and the moving conductor, and as the force required to move any object through a liquid is proportional to the square of the speed, it follows that the number of rotations of the conductor will be proportional to the current to be measured. The registering part of the apparatus may be independent of the above, and consists of an electro-magnet and armature similar to that of an electric bell, and arranged with a train of wheels. Each pulsation of the armature registers permanently.

5688. Improvements in Cymaphens or Apparatus for Transmitting Sound by Electricity, *C. F. Varley, Bexley Heath, and F. H. Varley, Mildmay-grove, Middlesex.*—27*th December*, 1881. 10*d*.

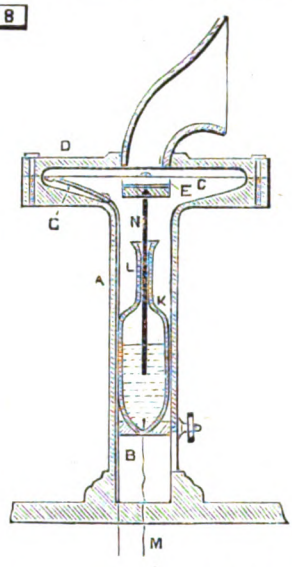
The figure shows one method of carrying out this invention. The style E projects through a carbon rod. On the end of E there is an adjusting nut for regulating the pressure spring B, which is made to press the carbon rod against the contact pieces C C¹. To the carbon rod an iron armature F is attached. Near F the poles N and S of an adjustable magnet are placed. These attract F and counteract spring B. Now,



if the magnet is powerful enough, it will overcome B and open the circuit between C and C¹. If the space between F and the poles N and S be increased the magnetic force is weakened, and spring B forces the carbon rod into contact with C and C¹. Thus, by regulating the resistance of N S and the force of B, any degree of contact pressure can be produced, and the most sensitive condition for transmitting sound by means of electric waves obtained. Many other methods of carrying out this invention are also described and illustrated.

688. Improvements in the Method of Transmitting or Reproducing and Repeating Sounds by Electricity, &c., *A. M. Clark, London.*—11*th February*, 1882.—(*A communication from G. M. Hopkins, Brooklyn, New York.*) 8*d*.

The first part of this invention consists in a contact surface attached to a vibratory diaphragm and a float-supported electrode pressed against the contact surface by a column of liquid. In the figure, E is a disc of carbon attached to the centre of the diaphragm C—metal or mica. If of metal, the diaphragm may be made part of the circuit by means of spring G. A glass bottle, K, is supported at any convenient height within A, as shown. A platinum wire, B, enters K, and is connected to wire M. K is partly filled with



mercury in contact with B, and which buoys up float-rod N carrying on its upper end a carbon disc. The float-rod is a conductor. This carbon disc is pressed by N into light contact with carbon disc E attached to C. Another part of the invention consists in two sets of electrodes insulated from each other and vibrated alternately in opposite directions, one set being placed in the primary telephonic circuit, and the other in the secondary, the object being to interrupt the secondary circuit so as to break up the effects of induction and render the induction currents and earth currents available in transmitting. Other improvements are described.

263,758. Process of Baking Carbon Rods, *Charles F. Brush, Cleveland, Ohio.*—*Filed May* 27*th*, 1881.

Claim.—(1) In the process of baking or calcining carbon rods or sticks, arranging the carbon rods or sticks in pyramidal form in a receptable and filling the interspaces and the spaces at the sides and ends of the pyramidal pile with suitable packing material, substantially as set forth. (2) In the process of baking or calcining carbon rods or sticks in a receptacle, arranging the carbon rods or sticks in pyramidal form on a slab or

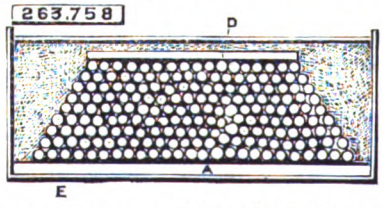
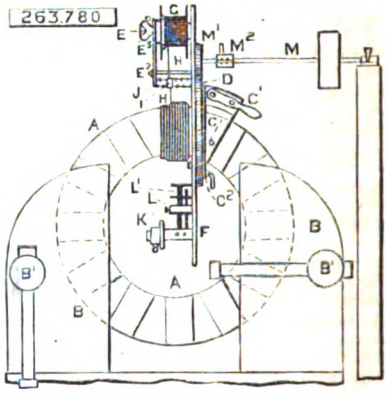


plate of suitable material to withstand warping, and filling the interspaces and the spaces at the sides and ends of the pyramidal pile with suitable packing, substantially as set forth. (3) In the process of baking or calcining carbon rods or sticks, arranging the carbon rods or sticks in pyramidal form on a slab or plate of suitable material to withstand warping, filling the interspaces and the spaces at the sides and ends of the pyramidal pile with suitable packing, and subjecting the pile to a superincumbent weight during the process of baking, substantially as and for the purpose set forth. (4) A pyramidal pile of carbons having the ends of its lower course formed of twin or connected carbons to prevent displacement, substantially as and for the purpose set forth. (5) The combination, with the pyramidal pile of carbon rods or sticks, of the supporting slab, the packing, and the enclosing box, substantially as and for the purpose set forth. (6) The combination, with the pyramidal pile of carbon rods or sticks packed in suitable material, of the supporting slab A, upper slab D, and enclosing the box E, substantially as and for the purposes set forth.

263,780. Machine for Winding Armatures for Magneto-electric Machines, *Robert Haase and John P. Recker, Indianopolis, Ind.*—*Filed August* 23*rd*, 1881.

Claim.—(1) The combination in a machine for winding wire upon annular armatures, of the divisable clamp C, constructed substantially as specified, and adapted to surround and be secured upon the rim thereof, and mechanism, substantially as described, secured to and adapted to revolve upon said clamps, substantially as and for the purposes set forth. (2) The combination, in a machine for winding wire upon annular armatures, of the surrounding clamp, the toothed rim, the arms thereon, the bobbin, a travelling guide, and an endless screw mechanism, substantially as and for the purposes set forth. (3) The combination, in a machine for winding armatures with wire in which one portion revolves upon another or stationary portion, of an endless screw or screws for driving a travelling guide, a star-shaped wheel upon the end of each screw, and projections upon the stationary part of the machine, with which said star wheel or wheels will come in contact as the revolving portion of



the machine moves past them, whereby said screws are revolved, the guide propelled, and the wire guided properly continually into place, substantially as set forth. (4) The combination, in a machine for winding annular armatures with wire, with the bobbin located upon one side of the centre of the revolving portion of said machine, of a weight L, upon the opposite side mounted upon a screw shaft L¹, having a star wheel L¹ upon its end, which comes in contact with points upon the stationary part of the machine as it revolves, whereby the position of the weight is continually varied to correspond to the decreasing weight of the wire, substantially as set forth. (5) The combination, in a winder adapted to revolve around the rim of an annular armature, of one arm carrying the bobbin for the wire and another arm upon the opposite side carrying adjustable counterbalancing weights, substantially as and for the purposes set forth. (6) The combination of the rim D, arm E, bobbin G, guide I, endless screws J J, having star wheels and stationary parts provided with projections, substantially as and for the purposes set forth.

2531. Improvements in Armatures for Dynamo or Magneto-electric Machines, *W. R. Lake, London.*—27*th May*, 1882.—(*A communication from J. J. Wood, Brooklyn, New York.*) 6*d*.

This relates to an improved method of securing the armature of the Gramme machine to its hub or shaft, and consists in the introduction at intervals of thin plates between the coil sections of the armature; these plates embrace iron cores and project into or are rivetted to the hub, thus producing a positive rotating connection between the armature and its hub, so as entirely to prevent the hub turning on the armature or slipping.

5400. Improvements in Electric Light Lamps or Lanterns, *T. Rowan, Coleshill-street, London.*—9*th December*, 1881. 2*d*.

This relates to a means for surrounding the light with prismatic lenses, so that it might be diffused around.

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SLIP

GRAPHITE.—A vein of graphite has been struck at Coromandel, New Zealand.

ETHER.—Dr. O. J. Lodge was to lecture on this subject at the London Institution on Thursday night.

THE TELEPHONE IN NORTH AFRICA.—The Compagnie Générale des Téléphones of Paris is establishing exchanges in Algiers and Oran.

ELECTRIC LIGHTING AT DRESDEN (SAXONY).—The pianoforte manufactory of Herr Emil Ascherberg, in Dresden, is lighted by means of the Edison system.

ELECTRIC LIGHTING IN ABERDEEN.—The principal streets of Aberdeen were lighted for the first time on Saturday last by means of the Brush system of electric lighting. The experiment is to be conducted for a period of four months.

NOTES ON THE ELECTRIC LIGHTING ACT.—We have received a copy of a work on this subject from the authors, Messrs. Clement Higgins and G. W. W. Edwards. We shall hope to acquaint our readers with its style and contents before long.

WEST INDIES.—The cable between Antigua and Guadeloupe is interrupted; and as the cable between St. Vincent and Grenada is not yet repaired, there is at present no telegraphic communication with Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, or Barbadoes.

THE EDISON SYSTEM IN BERLIN.—Ninety Edison lamps have recently been placed in the gas lanterns in Wilhelmstrasse, extending from the English Embassy to Prince Charles's palace. Each lantern has three lamps in it. The installation is, we believe, only experimental at present.

FIRE CAUSED BY ELECTRIC LIGHT WIRES.—It is stated that some cables leading to Brush lamps on Broadway, New York, recently came into contact with telegraph poles belonging to the Metropolitan Telephone and Telegraph Company, setting them on fire. No great damage was done, however.

THE FAURE COMPANY.—An interim dividend of 3s. per share has been declared by the directors of the Faure Electric Accumulator Company, payable on and after January 2, when the fully-paid shares in the proportion previously mentioned as to be given in exchange for the shares with £2 paid will also be delivered to applicants.

A HOLIDAY TASK.—We present our readers with a puzzle for New Year's Day. What German author defines magnetism thus? "Magnetism is centropheric antagonism, a radical line, $0, - — +$, the action of the line being cleft at one extremity. Magnetism has its root in the beginning of creation. It is prophesied with time."

THE TELEPHONE IN THE RIVER PLATE.—It is stated that arrangements have been made for the fusion of the interests on the River Plate of the Continental Telephone Company, of Boston, U.S., the purchaser of the rights, patents, and property of the Rio de la Plata Telephone Company and of the National Pan Telephone Company of Buenos Ayres.

NEW THEATRE AT CHESTER.—The new Royalty Theatre, to accommodate 2,000 persons, was to have been opened at Chester on Saturday night, but at the last moment it was discovered that the mechanical stage would not work, and several hundred persons had to be turned away. It is lighted by Brush lamps, which were tested and found to work satisfactorily.

ELECTRIC LIGHTING IN PARIS.—The proprietors of the Bon Marché in Paris have begun to replace gas in some of their departments by the Edison system. Five hundred Edison A lamps will replace as many gas burners in the basement and other parts of the building. It is stated that the telegraph office in the Rue de Grenelle is to be lighted by means of ten Cance arc lamps.

ELECTRIC LIGHTING FOR BIRKDALE (LANCS.).—The Southport Town Council have resolved that, in the event of the Birkdale Local Board proceeding with their application to the Board of Trade for a provisional order to supply Birkdale with electricity, the powers relating to the supply of that district contained in the order about to be applied for by the Southport Corporation be withdrawn.

THE TELEGRAPH AND TELEPHONE IN BRITISH GUIANA.—The *Colonies and India* says:—"On the introduction of a Bill to amend the present telegraph law, Mr. Russell said he feared its provisions would prevent the free introduction of telephonic communication, and the Government eventually consented to modifications to remove the presumed disability." The Bill was eventually read a third time and passed.

REMOVALS.—Edison's Indian and Colonial Electric Company have removed from their temporary offices at 6, Lombard-street, to Nos. 4 and 6, Throgmorton-avenue, Throgmorton-street, E.C.—The offices of the Gower-Bell Telephone, the Consolidated Telephone Construction and Maintenance, and the River Plate Telephone and Electric Light companies have been removed to the Telephone Works, Farringdon-road, E.C.

ELECTRICITY AND GAS AT AMSTERDAM.—We are informed that the Corporation of Amsterdam are in treaty for the purchase of the gasworks in that city, and that consequently they are looking with a somewhat cold and distant eye on matters electrical. Should, however, the present owners of the gasworks prove obdurate as to the purchase money to be paid by the Corporation, it is probable that the latter will warmly espouse electric lighting.

NEW COMPANY.—Articles of incorporation of the New York and Pennsylvania Telegraph and Telephone Company have been filed in the County Clerk's Office, New York. The new company is to construct, own, and maintain a line or lines of electric telegraph between New York and Erie, Penn., the principal cities on the route being Elmira and Binghampton. Its capital stock is now 50,000dols., divided into 500 shares of 100dols. each, but this may be increased to 1,000,000dols.

NEW SECONDARY BATTERY.—A secondary battery, invented by Messrs. Liardet and Donnithorne, has been on view at No. 38, Holborn-viaduct for some days. The main features of this battery are the intermixture of porous lead, deposited either by direct action by means of a galvanic current, or by the action of spelter, with oxides and salts of lead such as may be produced from galena or other lead ore. This mixture is placed on very thin plates of pure lead, and is kept in position by porous plates.

DEATH OF MR. C. V. WALKER.—Mr. C. V. Walker, F.R.S., past president of the Society of Telegraphic Engineers, and telegraphic engineer for the South Eastern Railway Company, died at Tunbridge Wells on Sunday, in the seventy-second year of his age. Mr. Walker was one of the oldest telegraphic engineers in the country, and was the inventor of several useful appliances, notably the instruments by which

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the block system on railways is worked. We shall hope to give some further account of his life in a future issue.

PRESCRIBING BY TELEGRAPH.—A correspondent sends us the following:—"An *employé* of the Eastern Extension Telegraph Company, stationed at Cape Bolimao, Manila, had a narrow escape the other day, having taken 10 grains of sugar of lead in mistake for a similar quantity of ammonia. He telegraphed for advice to the Hong Kong telegraph office. Dr. Hartigan of that city came down to the office, and sent him advice per cable, which resulted in his recovery. The distance between Hong Kong and Cape Bolimao is about 555 miles." Probably this is the first time that a doctor has prescribed for a patient over 500 miles away from him.

TELEPHONING FROM LONDON TO BRIGHTON.—On Thursday last (Dec. 21), the London exchange of the United Telephone Company was experimentally connected with the company's exchange in West-street, Brighton, wires being carried there from the railway station. Ordinary post-office telegraph wires were utilised with satisfactory results, conversation being carried on between the two places, and voices recognised. Some induction noises were experienced, but not to any very great extent. Congratulatory messages were received and exchanged between the mayor and Mr. J. P Knight, the general manager of the Brighton Railway. Several leading townsmen and men of business also tested the telephone.

COUNTRY REPORTERS.—A lecture on lighting by incandescence was delivered a few days since by Professor Jones, at Firth College, Sheffield. The lecture hall was lighted by Brush lamps, and a few of Swan's, the arc lamps being supplied by the Yorkshire Brush Company. The lecturer, as reported by a Sheffield paper, was made to say in describing the Swan lamp, that "Between the carbons, in this lamp, is placed a piece of marble, which is rendered incandescent by the electricity from the carbons. The points of the carbons are pressed against the marble by springs, and while the current is passing through the marble a reddish hue is imparted to the light," &c. The reporter, however, is not so very much to blame, as the "Sun" lamp sounds very much like "Swan" lamp when spoken.

THE TELEPHONE IN BOSTON (AMERICA).—The Telephone Despatch Company of Boston, encouraged by the success of experiments made last year with a cable laid between two stations on the Old Colony Railroad, has obtained authority for laying subterranean lines in all the principal streets of that town, and is about laying cables of different kinds in the immediate neighbourhood of its central office. The cables are enclosed in iron tubes 100 millimetres in diameter (about 4in.), and embedded in cement; eight tubes are laid side by side in each trench. Some of the cables are formed of a simple wire, insulated by means of paraffin, and enclosed in a leaden tube, whilst others are composed of a certain number of wires insulated by india rubber, and protected by a covering of galvanised iron wire; they are laid in tubes, and can be changed as often as required.

TRANSMISSION OF POWER.—A Glasgow contemporary mentions the following application of electricity to the transmission of power. It appears that Mr. Joseph Atkinson was some few months ago engaged fitting zinc sheathing to the shell of the ss. "Snark" by the process for which he is the patentee, in the shipyard of Messrs. Denny, of Dumbarton. Using a Siemens D 7 generator, driven by an ordinary donkey engine, Mr. Atkinson transmitted through 150 yards of insulated wire a power equivalent to about six horses to a small motor near the vessel's side. This motor, manufactured by Messrs. Siemens, from designs supplied by Mr. Atkinson, was made to revolve at a high velocity, and drove a flexible shaft attached to which was an emery wheel. With this wheel the hard surface of the vessel's shell, which was of steel plates, was highly burnished at intervals of 9in., with spots about 2in. in diameter, to which the zinc sheathing was afterwards attached by solder.

THE TELEPHONE CASE.—The *Daily News* recently published the following paragraph:—"Last May, Mr. Justice Fry, in the case of the United Telephone Company (Limited) *v.* Harrison, Cox-Walker, and Co., held that the Edison transmitter patent was void. Against this decision the United Telephone Company appealed, and we are informed they have to-day withdrawn their appeal." In reply to which the chairman of the United Telephone Company wrote:—"As the paragraph with regard to the withdrawal by the United Telephone Company of their appeal from the decision of Mr. Justice Fry is liable to be misunderstood, I shall feel obliged if you will allow me, on behalf of the company, to explain the facts. Mr. Justice Fry's decision was in favour of the company on all points relating to the telephone, and was adverse only because the phonograph was contained in the same patent, the claim for that instrument being held by his lordship to be bad on a technical ground. The phonograph has since been struck out by disclaimer, and upon the patent as it now stands Mr. Justice Fry's decision is in favour of the company on all points. The company has, therefore, no reason for desiring to disturb the existing decision."

THE TELEPHONE.—On Sunday night last Mr. W. Lant Carpenter delivered in the Queen's Rooms, Glasgow, the fourth of the present series of lectures under the auspices of the Glasgow Sunday Society. Mr. Lant Carpenter, whose subject was "The Telephone, the Microphone, and the Photophone," gave an interesting account of these instruments, illustrating his description by experiments. In speaking of Mr. A. Graham Bell, to whom he ascribed the invention of the telephone, he said his audience would be proud to learn that that gentleman was a Scotchman, having been born in Edinburgh, where his father, Mr. Melville Bell, was an elocutionist. Mr. Melville Bell had been led to contrive a universal alphabet capable of expressing any sound, and had ultimately intimated that he thought that alphabet could be used to train deaf mutes to speak. Having been asked to go to America in order, if possible, to carry out his scheme, he sent his son, Mr. A. Graham Bell, instead, who accordingly went to that country and started a school for that object. In the course of his work the latter gentleman had invented an instrument which gave a graphic delineation of sound by light cast on a mirror, and this invention, after various changes, described in detail by the lecturer, terminated at length in the construction of the modern telephone.

ELECTRIC LIGHTING IN MINES.—Messrs. Bell Brothers successfully tried for the first time, on Wednesday evening, says the *Newcastle Chronicle* for Saturday last, the electric light for illuminating the works both above and below bank at their Page Bank or South Brancepeth Colliery. The system used is that of the Maxim Weston Electric Light Company, and there are nine lights at bank on the pit heap and in the engine-houses, and 24 underground, 17 of these being in the Brockwell Pit at the shaft bottom, sidings, stables, and engine-house. The other seven are in the Busty Pit, similarly placed to those in the Brockwell. These lights are driven by a double engine, with a pair of 10in. cylinders

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with 20in. stroke, at a speed of 90 revolutions per minute, which gives 800 revolutions on the dynamo. This dynamo is capable of working 90 lights of 25 candle-power each. A second engine is in a forward state, and in the course of another week will be at work, when the whole of the surface works, colliery offices, managers' and engineers' houses, &c., will be illuminated with the electric light. The engines for working the dynamos are driven by steam, obtained from the waste heat of the coke ovens, which are close by. This enterprising firm are also engaged in making oil from condensed gases, drawn from the coal while burning in the ovens, and it is likely to be a commercial success.

Electric Lighting in Mills.—The agent of the Wamsutta Mills, writing to an American paper, gives the following figures with reference to the Edison system in use there:—"The plant cost about 12,000dols., and consists of three K dynamos, each of the capacity of 250 A lights of 16 candle-power each. One light serves four looms, giving an equal amount of light to each loom. In other parts of the mill the arrangement is such that one lamp lights about the same space as two four-foot gas burners. The whole system from the word go has moved along without a hitch. The agent says it is as cheap as gas at 1dol. per 1,000 feet, there is no smoke or heat from it, it is safer than gas, and it does not vitiate the air we live in. The dynamos are operated by one of the machinists, requiring but a small portion of his time. The power required is by actual test one horse-power for 8·6 lights of 16 candle-power each. The cost for power, taken in connection with the power to drive the mills, is very light, at the night end of the day. They are unable to detect any increase in the consumption of coal, but the fires are probably burned a little lower. The cost of lighting our mill, which contains 51,000 spindles and 1,072 40in. looms, putting the power at 30dols. per year per horse-power, is estimated as follows:—87 horse-power for 300 hours at 30dols., 261dols.; 375 lamps at 1dol. each, 375dols.; labour operating dynamos, 90dols.; interest and wear and tear on plant at 8 per cent., 960dols.; total cost of electric light, 1,685dols."

The Telephonic Administration of Oaths.—The administration of oaths by telephone is losing its novelty. On Dec. 4, in New York city, the Recorder so administered oaths to six physicians in a small-pox hospital, who were required to swear to the correctness of their accounts. "Have they all got their hands on the book?" asked the Recorder. "Yes, all ready," replied Dr. Hurd, the physician in charge. "Very well, then," said the Recorder, "you, as my deputy, repeat to the deponents what I say. You and each of you do solemnly swear ——." "You and each of you do solemnly swear ——" repeated Dr. Hurd. "That the annexed accounts are just, true, and unpaid ——" said the Recorder through the telephone. "That the annexed accounts are just, true, and unpaid," repeated the Doctor. "So help you, God!" said the Recorder through the telephone. "So help you, God!" repeated Dr. Hurd. "Now kiss the book," said the telephone. "Kiss the book," repeated the Doctor. The six hospital attachés kissed the Bible in turn. "They've all kissed it," said the Doctor, through the telephone. "They have!" answered the Recorder in surprise. "Why, I did'nt hear it. Let them kiss it again, loud enough for me to hear it." The kisses were repeated with an energy that sent the reports vibrating over the wire vigorously enough to be reproduced on the metallic disc at the receiving end. "I heard those. That's all right; good bye," said the Recorder, hanging up his ear-piece. An American contemporary remarks:—"Administering oaths by telephone is not a commendable practice, but if it is ever justifiable it is where one of the parties is in a small-pox hospital."

Electric Exhibition at the Westminster Aquarium.—We understand that this exhibition is shortly to be opened. For this purpose motive power to the amount of nearly 500 horse has been prepared by the direction of the Aquarium, and is being laid down in the buildings specially erected as machine annexes. The body of the hall of the Aquarium will be devoted to arc lighting, which will be represented by fourteen or fifteen systems, several of which are new. The space underneath the galleries and the galleries themselves have been sub-divided into courts for the purpose of exhibiting the several systems of incandescent lighting and fittings applicable to it. The ground floor of the whole of the building and parts of the galleries are apportioned out to exhibitors for the purpose of displaying the different applications of electricity, the most notable of which will be the motors, fourteen in all, which will drive machinery. The dining annexe will be lighted by Messrs. Ferranti, Thompson, and Ince with 350 incandescent lights, fed by one of their new dynamos. There is a series of five courts fitted up for the display of the Edison electric light and the different features of the Edison system. All the other courts are occupied by other firms to illustrate either new incandescent lamps or fittings for their use. The Metropolitan Brush Company have contracted to light up the Imperial Theatre during the course of the Exhibition, and we understand that their installation will be ready by the 6th January. Altogether the Exhibition promises to be of interest. From its situation it is very accessible for every one. We reserve further details for a future issue.

Dynamos.—The third lecture of the series on "Dynamo-Electric Machinery" was delivered at the Society of Arts on Monday week by Professor Silvanus P. Thompson, who took for his subject the dynamo as a motor. He said that efficiently to transmit power by electricity the generator and motor should be similar in construction in most respects. Uniform speed in the rotation of the armature of the generator was a desideratum, and gas engines which were driven by pulsations were not so desirable as other sources of power. Professor Ayrton had perfected a machine which was based on all the theoretical principles necessary for a machine to be self-adjusting whatever be the variation of work required from it; and it was his (Professor Thompson's) impression that a very near approach to perfection was arrived at in the combination employed in that instrument. In motors containing a single coil, such as the Griscom, Trouvé and Deprez, "dead" points were a great drawback. Boats had been propelled by electricity, and though Trouvé had abandoned the Planté secondary battery for the bichromate battery, the lecturer would not be more surprised to see large vessels propelled by electricity than those who saw the early beginning of steam would be if they awoke and saw how vessels were at the present day propelled by steam. Electric motors had only been used to a small extent to what they could be in places where steam or gas engines were undesirable or inadmissible, and the lecturer concluded by an expression of opinion that there was a greater future before electric motors than for electric lighting, and when a proper distribution of electricity through every town had been arranged, a far more potent agent would be possessed than was ever dreamt of, and people would then begin to realise how electricity could be utilised to meet their requirements. We shall give the first of this series of lectures with illustrations in an early issue.

The Electric Lighting Act.—As we predicted not very

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long ago, more than one local authority, fearing the responsibilities and expenses of electric lighting, has withdrawn its application for a "provisional order" under the Electric Lighting Act. If these cases of withdrawal are cases where the applicants had applied for powers to supply electric light to the whole of the area within their jurisdiction, a very wise course has been taken. But it is material to point out that it is not obligatory upon a local authority, or even upon a company, to apply for or take powers having so wide a scope. On the contrary, there seems to be no limit to the smallness of the area within which the powers of the Act may be exercised, and the local authority may supply the light to one part of a town, and a company to the rest of a town, or the rest of the town may be apportioned to as many companies as the Board of Trade please, or be left unsupplied with the electric light. The words of the Act (Section 4) are that "The Board of Trade may, from time to time, by provisional order, authorise any local authority, company, or person to supply electricity for any public or private purpose, within any area;" and all that the Board of Trade Regulations require under this head is (Rule 4 of October, 1882), that the draft application must contain, among other things, "a description of the proposed area of supply." When the area is allotted, and the order granted, the severe provisions of the Act as to compulsory supply and so forth may (or may not if the Board of Trade so please) be brought into force, and it is natural to expect that these provisions would be put in force in proportion to the size of the area. But it is obvious that an experiment could be better tried with a small and much-frequented area than a large one, and that such an area would, in many cases, need the light more than all the other streets of a town. We doubt whether withdrawing applicants would have power to recall their withdrawal, but if they should be unable to do so, perhaps recourse may be had to that provision of the Public Health Act, 1875 (Section 161), which enables an urban authority to contract with any person for the supply of "gas or other means of lighting" the streets—which "other means" must include the electric light—and so the local authority may be enabled to dispense with Board of Trade licences or provisional orders altogether. —*Solicitors' Journal.*

THE TELEPHONE IN NEW YORK.—We extract the following from an article under this head in a recent issue of *The Operator*:—"The Metropolitan Telephone and Telegraph Company confines itself to providing telephonic communication to subscribers, and to the construction, leasing, and maintenance of private lines in the city. On the latter, telephones, Morse, or printing instruments are used, as the lessees may prefer. They are not connected with the exchanges. The number of subscribers connected with the exchanges is at present about 3,000. The advantages of the telephone service to business men are shown by the facts that, while new applications for telephones come in at the rate of about 70 per month, the number of those who withdraw does not exceed five or six in the same period. Complaints of failures in the service are infrequent. The rental charged is 150dols. a year. This covers the entire service. The rate is uniform throughout the city. The company has nine exchanges distributed throughout the city. Subscribers' lines, as stated above, terminate at the nearest exchange, and the exchanges are connected by 270 'trunk' lines. All the lines are of No. 12 galvanised iron wire. A number of aërial cables span various parts of the city, the longest extending from Murray-street to Twenty-first-street, a distance of over two miles. Others are on Broadway, and several cross the Suspension Bridge to Brooklyn. Subaqueous cables in the North River unite New York and Jersey City; others are laid beneath the Harlem River. All of these are kerite cables, some having each conductor encased in tinfoil, while in others each separate conductor has, outside of the kerite covering, a thin coating of plumbago. These devices are found effective in suppressing inductive disturbances. With the exception of a manager and three switchmen in each exchange, the *employés* of the exchanges are all girls. In all, about 140 operators are employed, and 19 linemen keep the lines clear. Blake transmitters and Bell receivers are usually furnished to subscribers. Those who prefer Edison's instruments are furnished with them. The conversations between subscribers average 17,000 per day. The present, on account of its being the holiday season, is the busiest time of the year in the exchanges, which just now present scenes of remarkable activity. One Leclanché cell is usually furnished to subscribers; on long lines, frequently used, two Callaud cells are substituted. All cells are inspected and cleaned once a week by battery men, sent out by the company in waggons, except in the thickly-crowded districts, where they go on foot. In addition to the subscribers' lines the company has 29 lines which terminate in offices of the American District Telegraph Company, in various parts of the city, for the use of the general public. For five minutes' conversation with any subscriber in New York or Brooklyn a toll of 20 cents is charged; 25 cents to Jersey City, Newark, &c.; 30 cents to Elizabeth, Yonkers, &c.; and 35 cents to Plainfield, Sing Sing, &c. The system of the Law Telegraph Company extends over New York city and Brooklyn. This company uses the same instruments as the Metropolitan Company, and confines itself to telephony. It has 600 subscribers. The number of subscribers being limited by the terms of the company's license, no additions are made to this number. It has two exchanges in New York and one in Brooklyn. The rental to subscribers located within half a mile of an exchange is 15 dollars per month; to others from 15 dollars to 25 dollars per month, according to their distance from an exchange. This rental covers the entire service, including the lease and maintenance of the subscribers' lines. The lines are constructed of No. 11 galvanised iron wire. Some twenty-five 'trunk' lines connect the company's exchanges with each other, and about forty-five similar lines connect the exchanges with those of the Metropolitan Company. About two-thirds of the subscribers are members of the Produce Exchange, and the remainder are nearly all attorneys. The exchanges are only open from 8 a.m. until 6 p.m. Each subscriber has an exclusive wire. The company uses no cables. So compact and simple is the Law exchange system that five operators in each of the New York exchanges, and one in the Brooklyn exchange, are able to serve all the subscribers, although a record kept for the last three days of last August, at the request of the Committee on Statistics of the National Telephone Association showed the number of conversations between subscribers to average 6,000 a day. The system is rapidly coming into use in other cities. It is now used in Philadelphia, by the Bell Telephone Company of Philadelphia, which recently set up four Law tables, for 500 wires each. The Bell Telephone Company of Missouri uses the system in its St. Louis exchanges, where it has four Law tables for 400 wires each. It is also used by the Missouri and Kansas Telephone Company in its Kansas City exchange, and by the Southern Bell Telephone Company in various cities in the South, among which are Richmond, Charleston, Atlanta, Mobile, Montgomery, Savanah, and Columbus G."

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DRAFT PROVISIONAL ORDERS.

The Electric Lighting Act of last Session authorises the Board of Trade from time to time to grant *licenses* to local authorities, companies, or persons for the supply of electricity over a certain area under certain conditions. The Board of Trade may also from time to time authorise by a *provisional order* any local authority, company, or person to supply electricity over a certain area under certain conditions.

The applicant for a license must have the consent of the local authority having jurisdiction over the district for which a license is sought. The license expires at the end of *seven* years, but may be renewed.

The applicant for a *provisional order* must give notice to the local authorities of his intention to apply for such order, and the order is of no force until it is *confirmed by Act of Parliament*. The time during which a provisional order is in force seems to be unlimited, but provision is made by which the local authority may purchase at the expiration of twenty-one years—or earlier by agreement—and the powers then vest in the local authority.

The Act in Section 6 provides that:—

The undertakers shall be subject to such regulations and conditions as may be inserted in any license, order, or special Act affecting their undertaking with regard to the following matters:—

(*a*) The limits within which, and the conditions under which, a supply of electricity is to be compulsory or permissive.

(*b*) The securing a regular and efficient supply of electricity.

(*c*) The securing the safety of the public from personal injury, or from fire or otherwise.

(*d*) The limitation of the prices to be charged in respect of the supply of electricity.

(*e*) The authorising inspection and inquiry from time to time by the Board of Trade and the local authority.

(*f*) The enforcement of the due performance of the duties of the undertakers in relation to the supply of electricity by the imposition of penalties or otherwise, and the revocation of the license, order, or special Act where the undertakers have, in the opinion of the Board of Trade, practically failed to carry the powers granted to them into effect within a reasonable time, or discontinued the exercise of such powers; and

(*g*) Generally with regard to any other matters in connection with the undertakings.

Provided always that the Board of Trade may, from time to time, make such regulations as they may think expedient for securing the safety of the public from personal injury, or from fire or otherwise, and may from time to time amend or repeal any regulations which may be contained in any such license, order, or special Act in relation thereto; and any regulations so made or amended by the Board of Trade shall, from and after the date thereof, have the like effect in every respect as though they had been originally inserted in the license, order, or special Act, authorising the undertaking, and every regulation so repealed shall, from and after the date thereof, be repealed accordingly, but such repeal shall not affect any liability or penalty incurred in respect thereof prior to the date of such repeal, or any proceeding or remedy which might have been had in relation thereto. . . .

It will thus be seen that the rules of the Board of Trade have to be complied with to obtain a provisional order. These rules require proof of consent of local authority to application for a *license*.

They state that preference is given to applications from local authorities. They require publicity to be given to the application by advertisement, &c. Certain formalities must be gone through before certain specific dates. The draft order as proposed by the applicants must contain, among other things, information relating to area of supply, purposes of supply, description of the proposed works, the breaking up of streets, conditions of supply, cost, nature and amount of supply, obligation to supply, period of concession, safety of public and consumer personally and from fire, &c., provisions for enforcement of duties, &c. Various papers have to be lodged, and so on.

We may consider the Act and the Board of Trade rules as generalities, and the provisional order as the special and important work. The work, in fact, under which more directly the production and distribution of electricity is to be carried on. The provisional order sanctioned by Act of Parliament is as much law as the Lighting Act itself. The Electric Lighting Act is an entirely new departure. It authorises the distribution of "energy" for the first time in contradistinction to matter. The provisional orders, as allowed by Act of Parliament, next Session will be models for future draftsmen to use, and, therefore, it is extremely important that the "model" should be as perfect as possible. We have before us a "draft provisional order" similar to those lodged in accordance with the Board of Trade rules. This order has been drafted by one of the ablest lawyers, who at the same time is well versed in scientific matters, and who has given special attention to the developments of electricity. The draft shows that an immense amount of pains has been taken to fulfil the conditions determined by the Act and by the rules of the Board of Trade. The interests of the public no less than the interests of the applicants have been considered, and so far as we can at present judge the draft order seems to be complete and little open to unfavourable criticism. We shall now briefly abstract the order, giving the salient points in full, so that any reader may be able to criticise fairly, and we are sure that genuine criticism will be thankfully received by all who are interested in electric lighting. The order commences with formal clauses giving title, address of applicants, and description of area it is proposed to supply. It then proceeds to consider the general powers to be observed to enable the undertakers to manufacture, repair, let on hire, sell, supply, erect, maintain the apparatus, to make contracts, to take up streets and lay down wires, to erect the works, and so on. The primary object of the supply of electricity is for lighting purposes, but the undertakers "may supply electricity for all public and private purposes."

The nature and mode of supply is described under the following systems:—

(*a*) The *Direct System*, which is the name adopted for the simple "multiple arc" system. The conductors leading from the mains to the consumer's premises are called *service lines*, and the portions of such mains which are used for the purpose of giving origin to the service lines are called *distributing mains*.

(*b*) The *Storage System*, that is utilising reservoirs or storage batteries placed on the premises and under the control of the undertakers. The mains used for charging these storage batteries are called *charging mains*.

(*c*) The above but with earth returns.

(*d*) The *Series System*. In this system, as is well understood by electricians, the lamps are in succession in the same circuit. The consumers have not, as in the direct system, separate and independent circuits, but are dependent on the one circuit.

In addition to the above, any other system of distribution can, by agreement, be used. The undertakers supply to two poles or terminals upon the consumer's premises, past which terminals their liability does not extend. An important section makes optional the use of distributing and testing boxes. These are boxes placed at intervals in connection with the mains, and from these boxes the service lines are taken, and from these boxes, mains, service lines, charging lines, &c., can be tested, and connections made or broken, &c. The use of such boxes obviates the necessity of breaking up the streets, or breaking into the main conductor in order to connect house or branch lines.

The undertakers *shall* lay down, maintain, &c., suitable distributing mains in certain specified streets (these streets are named in Schedule A), also *shall* (if required by local authorities) arrange for the public lighting of specified streets either by the incandescent or arc system, at a price to be agreed upon or settled by arbitration. In addition, the undertakers *may* lay down and maintain, &c., distributing

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mains in streets, &c., in area specified. If the work is not done in three years the Board of Trade may call upon the undertaker to carry out the work in the optional districts, provided the work can be done at a reasonable profit. A provision is made so that the Board of Trade can, if it sees fit, strike out the names of any streets, &c., they consider it advisable not to retain. The time during which the supply is to be guaranteed will, of course, differ in different districts. This has to be stated in the order, but is obviously a matter of detail and not of principle. The supply has again to be distributed at a standard difference of potential, which again differs according to the system adopted and the conditions in vogue. The standard may be different for different points in the mains, and for different hours during the period of supply. A variation of 10 per cent. is the limit of variation for the difference of potential. The resistances of the service lines are to be such that they will not cause more than 2·5 per cent. difference of potential between the consumer's terminals. The case of "alternate currents" is provided for, as is time for testing. The owners of premises within *fifty feet* of a distributing main can demand a supply of electricity—this demand does not hold with regard to a *charging main*. The consumer has to state the maximum current he requires, and the undertakers can refuse to supply a greater maximum than can "reasonably be required." If the maximum exceeds *fifty amperes* the same will be given off at more than one set of terminals, so that the maximum current at any pair of terminals shall not exceed "fifty amperes." Before referring to the conditions as to price, it may be said that generally meters of approved construction are to be used, and that these meters are to be under the control of the undertakers. It is extremely interesting to have a definite reply to a questioner who asks, How will the companies charge for the current? In the draft before us, Section 34 and Schedule C deal fully with this. The section states that the undertakers may elect to charge by one or other of five systems, or otherwise by agreement. The schedule gives the unit and the maximum amount that can be charged. The systems are—

(1) By the quantity of energy contained in the supply.

(2) By the actual quantity of electricity so supplied.

(3) By the number of hours during which the supply of electricity is actually used by the consumer and the maximum current required to be supplied.

(4) By a yearly or other rental, depending upon the maximum current required to be supplied.

(5) By a charge which is calculated partly by the quantity of energy contained in the supply and partly by a yearly or other rental depending upon the maximum current required to be supplied.

It may, perhaps, conduce to clearness if we now give

Schedule C.

The term unit, as used in this schedule, shall be deemed to mean the energy contained in a current of one thousand amperes flowing under an electromotive force of one volt during one hour.

Section I.—In case the undertakers shall elect to charge any consumer by the quantity of energy contained in the supply given to him, they shall be entitled to charge him at the following rates per quarter of a year:—For any quantity up to one hundred units, three pounds fifteen shillings, and for each unit over one hundred units ninepence per unit.

Section II.—In case the undertakers shall elect to charge any consumer by the actual quantity of electricity supplied to him, they shall be entitled to charge him according to the rates set forth in Section 2 of this schedule; the quantity of energy contained in the supply given to him being taken to be the product of the actual quantity of electricity supplied to him and the standard pressure at the point of junction of the mains and the service lines by which he is supplied.

Section III.—In case the undertakers shall elect to charge the consumer by the number of hours during which he shall actually use his supply, they shall be entitled to charge him at the rates specified in Section 2 of this schedule; the quantity of electricity supplied to him being calculated on the supposition that the consumer uses the maximum current specified by him under the provisions of Section 27 during all the hours that he has used the supply.

Section IV.—In case the undertakers shall elect to charge the consumer a sum by way of yearly or other rental, they shall be entitled to charge him the rates specified in Section 3 of this schedule; the number of hours during which he has taken the supply being taken to be *three-fourths* of the number of hours during which the supply was continued during the period to which such rental relates.

Section V.—In case the undertakers shall elect to charge the consumer by the method set forth in Section 34, Subsection (5), they shall be entitled to charge as follows:—At the rate of thirty shillings per annum for every ampere in the maximum current, in case the supply is given at a standard pressure of not more than 100 volts, and at a price higher in proportion to the standard pressure in case such pressure is more than 100 volts, and in addition thereto a charge of sevenpence-halfpenny for every unit actually used.

It is somewhat out of our province to discuss the pains and penalties clauses, suffice it to say that consumer and undertaker can be punished for wrong-doing—for omissions or commissions. The regulations as to safety, &c., contained in this draft order state—

(*a*) That the maximum current for distributing or service lines is 2,000 amperes per square inch of section of pure copper wire of equal conductivity.

(*b*) That leakage must not exceed 10 amperes per mile run.

(*c*) That the lines shall be waterproof, and protected from injury.

(*d*) That the circuit may be broken at some point outside the premises.

(*e*) That fusible safety plugs shall be used, so that the circuit is broken when a current 100 per cent. (or less, as seems fit to undertakers) over the maximum current the line is intended for goes through it.

(*f*) The terminals to be of an approved pattern, and not less than 3in. apart.

(*g*) When earth returns are used the earth contact to be good.

(*h*) Difference of potential at corresponding points of distributing or service mains not to exceed 300 volts.

(*i*) Difference of potential of charging mains not to exceed 4,000 volts.

Or as agreed upon and approved by Board of Trade for arc lighting.

Within buildings:—

(*a*) The conductors are to be such that the maximum current at any time shall not exceed 2,000 amperes per square inch of section of a pure copper wire of equal conductivity.

(*b*) No part of conductor to be naked and unprotected.

(*c*) Conductors laid within *six* inches of walls, &c., to be insulated with a covering giving a minimum insulation for whole building of not less than 5,000 ohms per volt in the standard pressure at the junction of mains and service lines. The covering to be waterproof, and have an external fireproof covering.

(*d*) Apparatus to be insulated.

(*e*) Conductors (except at terminals) to be not less than *one* inch apart.

(*f*) Resistance of circuit not to be below a certain specified point.

(*g*) No part of circuit to be put to earth.

(*h*) If earth returns used, no part of circuit to be put to earth except through pole of earth return.

It will, we think, be admitted that the draft order, with parts of which we have thus briefly dealt, is worthy of careful consideration, and is no mean achievement of the draftsman.

Electric Lighting in Charleston (America).—The United States Electric Light Company began lighting the streets of Charleston, S. C., Dec. 5. The company now have 36 arc lights for street lighting, and 15 in the Agricultural Hall Building, and 107 incandescent lamps also in the Hall.—*Sanitary Engineer* (New York).

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MAGNETIC FORCE AND CURRENT.—III.

BY OLIVER HEAVISIDE.

In the previous articles under the above title (pp. 6 and 32) we explained the nature of two operations of frequent occurrence in electro-magnetism, viz., from a given vector-function to derive its "curl," and also to find its vector-potential; and some of the relations of these functions were mentioned. But that was for descriptive purposes merely; the only proof that curling the magnetic force gave rise to the current was that derived from the known magnetic force of a straight current, together with the assumption of a certain distribution of force within the current itself. [It was stated, by a slip, that the magnetic force within the current was "known" to be so-and-so, as if it could be measured at the spot, like the external force.]

We have now, to make the matter a little more complete, to prove that the properties ascribed to the vector-potential of current and its curl are really true, and to further develop them. It need not be thought that a knowledge of mathematical analysis of a high order is required, for it so happens that nearly the whole of investigations in electro-magnetism (although they may be of a very involved nature, the causes whereof were briefly alluded to on p. 55) are, when resolved into their simplest forms, merely the application in various shapes of the three theorems given on pp. 55-7; and these theorems are of such a nature that they may be reasoned out mentally, without symbolical aid save for final expression; and, in fact, in thinking them out in this way we may obtain a far clearer conception of what the theorems really mean than by working them out analytically, blindfolding the mind, so to speak, and working mechanically. No disparagement is intended of strictly symbolical demonstrations, or of the labours of the great mathematical electricians. To use a simile which may be readily applied, when once a bold explorer has reached the top of a hitherto inaccessible mountain, by circuitous paths and with the expenditure of great labour, others can do it after him, and easier routes may be discovered; and in course of time people may travel up comfortably seated in railway carriages. And, of course, it is still easier to start from the top and travel down. (A fall down a precipice, in seeking a short cut, may be compared to an abrupt breach of continuity in the reasoning.) A sound knowledge of the fundamental *principles* of the Calculus is desirable, but, so far as general results go, apart from special, very little of the *practice* thereof, for differentiations and integrations are usually merely indicated, not performed.

We have, in the first place, to clearly conceive what is meant by a flux of no convergence, and this is best done by means of a material analogy. Think of a frictionless, incompressible fluid filling all space. Within a given volume there must be always the same amount of fluid. If, then, we suppose the volume fixed in space and the fluid to be in motion, the same amount of fluid as enters it through its surface at some places must leave it at others, in any given time; or, algebraically, the total flux through the closed surface from within outwards must be *nil*. This is self-evidently true for any closed surface anywhere situated, and however the fluid may be moving. The flux through the surface of the element of volume is $= \frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} \times$ volume per second, if X, Y, Z are the component velocities in the directions x, y, z (Theorem I., p. 56), consequently $\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = 0$ in the case of an incompressible fluid.

If we have any vector or directed quantity, R, components X, Y, Z, and we say that $\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = 0$, or that it has no convergence, we simply imply that the distribution of R is similar to that of velocity in a possible case of motion of an incompressible fluid, so that we may, without going wrong, guide ourselves by the material analogue.

We may represent the fluid motion by means of lines, their direction showing that of the motion, their density the velocity. Or, rather, this is a convenient method of imagining the motion, because, if we draw the lines on a sheet of paper, we can only strictly represent in this way the nature of the motion in a section of the fluid bounded by two close parallel planes, and we may require a different diagram for another part of the fluid. We may, indeed, represent on paper the distribution in three dimensions according to Maxwell's system, but this has the disadvantage of requiring interpretation, for in many cases it makes the lines densest where they (in a plane section) would be furthest apart. Similarly, we may employ lines to indicate the distribution through space of any vector magnitude, R. When there is no convergence anywhere the lines form closed curves. We may, indeed, imagine lines of force to go out to infinity, and so get lost sight of. Thus we may imagine an indefinitely long, straight current coming from $-\infty$ and going to $+\infty$, and the corresponding lines of vector-potential will behave similarly. But this is not realisable. However long the straight portion of the current may be, it must ultimately return to the starting point, when the lines of flow will form closed curves; and, at the same time, the lines of vector-potential will also do so.

We have next to consider vectors that have convergence. In an incompressible fluid this would imply that at a place of convergence more fluid arrived than left in a given time, or *vice versâ*, and that would mean that fluid was perpetually going out of or coming into existence at the place—an annihilation or creation of fluid. Places of convergence are, therefore, sources or sinks. In a field of electric force, *e.g.*, that between two charges $+e$ and $-e$ on insulated conductors, the lines of force start from the surface of one and terminate on that of the other. They do not form closed curves. In the dielectric between the conductors, the force has no convergence. Imagine any closed surface entirely in the dielectric, every line of force which enters the enclosed space leaves it again. Such a line is the representative of a tube of force, across every section of which the same amount of force passes. But if the closed surface be partly within and partly without one of the conductors, say the +, a certain number of lines of force leave it on one side and *none* enter it upon the other side; there is, therefore, negative convergence, and similarly at the − conductor there is + convergence. The amount of convergence per unit of surface is a measure of the negative electrification. In any vector-system R, the quantity $-\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right)$ is a measure of the convergence at any place, expressed for a unit volume.

[The corresponding expression for unit of surface is $(R_1 \cos \epsilon_1 + R_2 \cos \epsilon_2)$, where R_1 and R_2 are the values of R on opposite sides of the surface, and ϵ_1, ϵ_2 the angles R_1 and R_2 make with the normals drawn *to* the surface from opposite sides. $R_1 \cos \epsilon_1$ is the amount of R reaching the unit of surface from one side, and $R_2 \cos \epsilon_2$ from the other side. In the case of no convergence these quantities are numerically equal, but of opposite signs, so that $R_1 \cos \epsilon_1 + R_2 \cos \epsilon_2 = 0$; corresponding to $\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = 0$.]

To further illustrate the distinction between converging and non-converging vectors, consider a linear current with its ends immersed in a conducting medium. The lines of flow in the medium from the + to the − end are exactly similar to the lines of force between the two charges $+e$ and $-e$ before considered, so that if we were to ignore the linear current there would be + convergence at the place where the current enters the wire and − at the other end. Similarly, if we ignored the current in the medium, we should have convergence at the ends of the wire of opposite sign to the last. But, considering the complete system, there is no convergence anywhere, the above convergences cancelling. In the static electrical case there is no channel joining the conductors to make a complete circuit for the force, so there is really convergence.

It will be convenient, preliminarily, to alter the definition

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of potential. Instead of the potential of any agent e at distance r being $\frac{e}{r}$, let it be $\frac{e}{4\pi r}$. If e is a scalar, so is its potential; if a vector, its potential is also a vector, to be drawn parallel to direction of e. In the case of electric force, this definition of potential implies that the force at distance r is of strength $\frac{e}{4\pi r^2}$, so that the whole amount of force leaving e is numerically equal to e. Now, the whole amount of force leaving any space is independent of the distribution of the free electricity within it (p. 55), and is numerically expressed by the amount of the latter. Expressed for a unit-volume, we now have (Theorem I., p. 56)

$$\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz} = \rho \quad . \quad . \quad . \quad . \quad (1),$$

ρ being the volume-density, so that $-\rho$ measures the convergence.

We shall now prove an important property of converging vectors having no curl. Let a vector be denoted by R, and suppose it is given in direction and magnitude throughout all space. Measure its convergence everywhere; *i.e.*, divide all space into elements of volume, find the excess of the amount of R, leaving any one of them over that entering it, and denote it by ρ per unit volume. Then we have Equation (1) again, where, however, ρ does not now mean the density of free electricity, but merely the convergence (with sign reversed) of the vector R. ρ is then known everywhere, being 0 at those places where there is no convergence. Next, let R have no *curl* anywhere. The line-integral of R once round any closed curve is then $= 0$, by Theorem II., p. 56; therefore, the integral of R from any one point A to any other Z is the same by any path, being determined solely by the position of A and Z; therefore, by Theorem III., the integral of R from A to Z $= P_A - P_Z$, where P is a scalar function of position, and the component of R in any direction s is $-\frac{dP}{ds}$. The direction of the resultant R is that in which P decreases fastest, and its magnitude is the rate of decrease. We may denote the resultant vector by $-\nabla P = R$, with components $-\frac{dP}{dx}, -\frac{dP}{dy}, -\frac{dP}{dz}$ in the three rectangular directions x, y, z.

The question now arises, how is the quantity P to be determined, starting with ρ given, and that R has no curl; *i.e.*, what is the explicit relation of P to ρ? If we consider a single element of volume, a unit cube for example, taking the unit indefinitely small, ρ is the excess of the amount of R, leaving it over that which enters. Now, disregarding altogether the manner in which R really enters and leaves the pace, let the quantity ρ give rise to a vector R′ in the same manner as free electricity gives rise to electric force, *i.e.*, let $R' = \frac{\rho}{4\pi r^2}$ at distance r from ρ, and be directed along r from ρ outwards, so that the whole amount of R′ leaving ρ is numerically $= \rho$. Let the same thing take place wherever there is convergence, and then find the resultant, *i.e.*, the vector-sum of $\frac{\rho}{4\pi r^2}$ or $R' = v.\Sigma\frac{\rho}{4\pi r^2}$ This new vector R′ obviously satisfies the condition expressed by Equation (1) above; by the manner of its construction the convergence anywhere is $-\rho$, for those of the lines of R′ which proceed from centres lying *outside* any one of the elements of volume which enter the latter leave it again.

Now, $\frac{\rho}{4\pi r^2} = -\frac{d}{dr}\frac{\rho}{4\pi r}$; *i.e.*, the flux from the element ρ is derived from the potential $\frac{\rho}{4\pi r}$, for the latter plainly decreases fastest along r outwards, and its rate of decrease is the strength of the assumed flux. Form next the sum of the potentials as above for all the elements, or $\Sigma\frac{\rho}{4\pi r}$ and call it P; then since

$$-\nabla\Sigma\frac{\rho}{4\pi r} = -v.\Sigma\frac{d}{dr}\frac{\rho}{4\pi r} = v.\Sigma\frac{\rho}{4\pi r^2},$$

therefore $R' = -\nabla P$.

We have thus found a scalar potential whose variation in space is a vector R′ which has the same convergence as R, and we may now easily prove that R′, like R, has no curl. For, by the general equations (Theorem II, p. 56) connecting a vector and its curl, the x-component of the curl of R′ is

$$\frac{dZ'}{dy} - \frac{dY'}{dz} = \frac{d}{dy}\left(-\frac{dP}{dz}\right) - \frac{d}{dz}\left(-\frac{dP}{dy}\right) = 0 \text{ identically,}$$

and similarly for the y and z components.

Now, is it possible for R′ to differ from R? If they do differ, let R″ be the difference. It must have *no* convergence, because R and R′ have the *same* convergence. But if R″ had convergence, some of the lines of R″ would terminate at certain places; therefore, having none, the lines of R″ must be closed curves. But if we integrate R″ once round one of these closed curves, we obtain a finite quantity, because the direction of R″ at any place coincides with that of the curve. But R and R′ have no curl, hence their difference R″ has none, consequently the line-integral of R″ round *any* closed curve is *nil*. Thus the lines of R″ cannot be closed, and since also they cannot terminate anywhere, it follows that they do not exist. Therefore, R″ is non-existent, and R′ = R identically. That is,

$$R = v.\Sigma\frac{\rho}{4\pi r^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

is the complete solution of (1), with the condition that R has no curl.

Now, if in (1) we put for X, Y, Z their values in terms of P, viz., $-\frac{dP}{dx}, -\frac{dP}{dy}, -\frac{dP}{dz}$, we obtain

$$\frac{d^2P}{dx^2} + \frac{d^2P}{dy^2} + \frac{d^2P}{dz^2} = -\rho \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Therefore, we have also found a solution of this last equation, viz.;—

$$P = \Sigma\frac{\rho}{4\pi r} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

It may be shown that any other solution of (3) can only differ from this one by a constant quantity. For if there be another solution, say P + P′, then $-\nabla P'$ must have no convergence anywhere, because the convergence is fully given by that of $-\nabla P$ or R; and it must have no curl anywhere, because like R it is derived from a scalar potential; therefore, by the same reasoning as that proving that R″ was non-existent, we see that $-\nabla P'$ is non-existent, and hence P′ must be constant everywhere. This constant allows us to locate the zero of P where we like, it is most convenient to put P′ = 0, so that P = 0 at an infinite distance from places where ρ exists, and then (4) is the complete solution of (3).

(TO BE CONTINUED.)

ELECTRIC LIGHTING FOR SUNDERLAND.—The Sunderland Town Council have adopted a report from their Highways Committee, recommending them not to apply for either provisional order or license, but to authorise the committee to negotiate with electric lighting companies to supply the electric light within the borough on the best terms they can.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

XI.

It is necessary to call attention to a point in connection with the use of the short circuit key referred to in the last number of this series, and in so doing we desire to impress on the learner the importance of taking at the outset a correct view in relation to detail. What some persons call "little things" or "trifles" not worth troubling about should have no place in his estimation. As a grain of sand might disturb the working of a complicated machine, or even cause its destruction, so the neglect of some apparent trifle in the course of a testing operation will prevent the attainment of a correct result. One of these "little matters" is concerned in the condition of the contact pieces in testing keys, and any instrument in which a circuit is continued by the contact of two little platinum pips. This metal is employed for the purpose, chiefly because it is less heated by the passage of a current than other metals; the points are thus kept cleaner, and freer from oxide than if they were of inferior conducting quality. When the short circuit arrangement just mentioned is employed, care should be taken that all these points are perfectly clean and fit well, that is, that the upper and lower contacts should accurately meet and touch each other firmly when caused to do so. In Fig. 21 (No. X.) the contacts of the short circuit piece are placed one on the under side of the bar, and the other on the upper side of the key piece. If these are not quite clean, if any dust settles on either, perfect contact is not effected, and the galvanometer is not properly protected in case of a current passing in the circuit. If a current passes while the galvanometer is supposed to be short circuited, there ought to be no deflection on the scale until the key is depressed. But if the caution is not observed a deflection will appear, though the short circuit is open, and the learner would certainly be in a difficulty if he did not know the true cause. It would be awkward if this happened with a cable connected up in circuit, for it would be charged, and the test could not be properly taken under the circumstances. The only safe course would be to take off the battery (free the battery key) and put the cable to earth for a time, postponing the test till it were thoroughly discharged.

In the course of our remarks on the "constant" we stated that the current passing in a circuit, and consequently the deflection given by the galvanometer through which it goes, is larger or smaller as the resistance in circuit is smaller or larger, so that, of two resistances, the larger would give a smaller deflection than the other. Now, we have shown that the deflections when testing cables for insulation resistance are larger when a long cable is in question than when a shorter one is observed. These two statements may, and most likely will, appear to the learner to be contradictory; but, if he has understood the remarks in which we compared the relation between the resistance per knot and the total or absolute resistance as regards conduction and insulation, he will not long feel doubtful as to the facts. It is evident, as observed in No. IX., that the longer a cable is the greater is the facility for leakage, as every additional knot gives additional opportunity for the escape of the current through the insulating cover. Therefore the resistance to this leakage is more and more broken into, so to speak, or opposed as the power of leakage is increased; and as the total resistance decreases the current increases (supposing the same battery power to be employed). The resistance for every knot obviously remains constant if every added length is precisely similar to the previous lengths of any one cable; for if one knot of cable gave a total insulation resistance of 500 million ohms—that is, 500 millions per knot—five knots of the same would give a total of 100 millions, still 500 millions per knot, and 10 knots would have a total or *absolute* resistance of 50 millions or 500 millions per knot. This shows that, in comparing one cable with another, similar in all but length, the longer will have the smaller absolute insulation resistance, and must, therefore, cause a larger deflection under the conditions suggested. The one knot just mentioned has the resistance per knot all concentrated as it were in that length; the longer cables having the same resistance per knot must have a proportionally less total resistance, this total being divided by so many additional knots, each of which reduces it. Any difficulty about this matter arises from confusing the conductive and the insulation resistance. A beginner seems naturally to conclude that the reason why a longer cable gives a larger deflection than a short one is because its resistance is greater, whereas it is just the reverse. He would see this at once if, instead of passing a current through a million ohms as he did when finding the constant, he used a smaller resistance, as eight or nine hundred thousand. His deflection would be larger—instead of 300 divisions, as suggested, he would get, probably, 400 or more. We have discussed this point somewhat at length to prevent any confusion of ideas which we know is felt by many who can take an insulation test but are uncertain about its meaning.

It has been stated that a megohm is generally used for taking the constant in this test. This amount of resistance is not a single coil of wire of a million ohms, but consists of 10 coils each of 100,000 ohms contained in a box and so arranged that one or any number of them can be put in circuit as required. If there should not be a megohm at hand the constant must be found by the next best method. A resistance box with 10,000 ohms is always to be found in the testing room, and with this the operation can be performed. It is necessary to use the same battery power as that employed for testing the cable, but if a current from 200 cells were permitted, the deflection would be far beyond the limits of the scale. The proper course under these circumstances is to find the E.M.F.* of the 200 cells, that is, to find how much stronger the whole number is than one cell; for in any number of cells joined up together we should never find all of equal strength, and 200 would not give a deflection 200 times larger than that given by one of the number. We must postpone explaining how to measure the E.M.F., and assume for the moment that the whole battery is 180 times stronger than one cell. We will now join up one cell, with a resistance of 10,000 ohms and a shunt, not forgetting to put one end of the resistance to earth by a leading wire. On depressing the battery key a deflection will follow, its value being regulated by the resistance of the shunt. We will suppose a shunt of a certain resistance gives a deflection of 300. This amount multiplied by the multiplying power of the shunt will give us the number of divisions which this one cell would give if no shunt had been used. As the E.M.F. of the 200 cells is 180, by multiplying the value just found by 180 we get the number of divisions which the 200 cells would give through 10,000 ohms if no shunt were employed. To find the actual value of the constant we must again multiply this last value by 10,000, and we have the amount in millions. At first sight, this may not appear to result as a matter of course when comparing the explanation in No. IX., where the constant was obtained by operating with a million ohms directly. In that example we found the value at one operation, and the learner may not at once see clearly that we should get the same value whether we used 10,000 or a million ohms through which to test. Turning back to that example, we found that, with the 200 cells, we had 300 divisions, with a shunt of 150 multiplying power through one million ohms, getting thus 45,000 as the number of divisions which would have resulted if no shunt had been used. We therefore multiplied this by one million to get the value in millions. Let us now see what number of divisions we should have as the deflection with the same battery through 10,000 ohms only, if no shunt were used. Remembering that the strength of the current, and, consequently, the deflections caused by it, increases in the same proportion as the resistance of the circuit decreases, it is plain that we should have a deflection 100 times larger than that obtained when the million was employed—instead of 45,000 it would be 4,500,000—multiplying this by 10,000, we have 45,000 millions, as before; or 4,500,000 in tens of thousands is the same as 45,000 in millions. In this comparison we have merely worked with the calculated values, which in practice we could only obtain

* The expression for electromotive force.

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by the devices previously explained, such as the shunts and the necessity for using one cell with the 10,000 ohms resistance. It would be difficult to get precisely the same amount for constant if both processes were tried, though we have assumed the fact. If with the megohm and 150 multiplying power we have 300 divisions, we ought with the ten thousand to use a shunt of 15,000 multiplying power to give us the same number of divisions, and we could only do this by using one cell first and calculating the value for the whole battery. To carry out a comparison of the two operations fairly the value for the battery should be considered for both.

We may finally look at them in another way, which will also give additional light if any uncertainty yet lingers in the learner's mind. The strength of the current C is represented by the deflection, and it is or varies inversely as the resistance R and directly as E the E.M.F. In reducing this statement to the form of an equation we may regard E as representing or standing in the place of the constant, for it is equal in both cases. We suppose the same battery power to be used, first with the megohm and then with the 10,000 ohms, and the constant is that which results from the employment of this particular E.M.F. Instead, therefore, of writing $C = \frac{E}{R}$, we may put it in the first case $300 \times 150 = \frac{E}{1 \text{ million}}$, or $45{,}000 \times 1$ million $= E$, which stands for "the deflection we should get without shunt is directly as the power determining the constant and inversely as the resistance in circuit," or reducing, "45,000 millions is proportional to or measures the constant required."

In the second case, $300 \times 15{,}000 = \frac{E}{10{,}000}$, or 45,000 millions is the constant. The resistance of both battery and galvanometer is omitted, as is often the case in practice.

In order to show that he thoroughly understands the meaning and course of action of this test, more especially when applied to a cable, the student should be able to answer the question, "Why does the spot move first in one direction over the scale and then immediately commence returning and constantly move back again towards its starting point?"

The action is as follows:—When the cable is charged by depressing the battery key, and the current is also allowed to pass through the galvanometer coils by removing the short circuit plug (or putting down the short circuit key, as the case may be), a deflection, say towards the right hand, immediately follows. The battery key being kept down, the current constantly passes, always in the same direction, through the galvanometer; but the deflection has changed and is towards the left hand. Knowing that this will last while the current is kept on, the learner's first idea would probably be that the spot is, as it were, being constantly driven back by it, as if its passage through the galvanometer were reversed. If the short circuit plug be returned to its place, and the current thus be cut off, the spot returns to zero at once, and it would be just the same if the direction of the current had been originally on the other side. The return to zero is in the same direction as that in which it had been previously moving. Again, if when the cable was charged and the path through the galvanometer was open, any conducting matter in connection with earth touched the end of the copper conductor, the charge would be put to earth, and the spot would rush away in the direction originally followed when the battery key was first put down. Taking these facts into consideration the answer to the question is presented, if, at the same time, the conditions of a cable in view of its identity with a condenser are remembered. We remarked in a former number that an insulation test was in one sense similar to a copper resistance test, inasmuch as in both cases a complete conductive circuit was formed (see Fig. 19). But though sufficient for a fairly good understanding of the former test by a beginner, it is a fact that other conditions are involved, the consideration of which would carry us too far at present. We must be content with saying that the first deflection seen after charging the cable is due to the rush of the current to effect this charge, and the apparent backward movement of the spot is caused, according to one view, by the increasing resistance presented by the insulating cover, thus tending to lessen the deflection, and as others think by a compound influence depending on various conditions. Anyhow, the deflection is really always in one direction from the first, and it is not forced back by the current, but its position on the scale is the result of a balance of forces mutually contending.

In the next number of the series we shall consider the operation of joint testing.

CROMPTON'S COMPOUND MACHINE.

BY GISBERT KAPP.

(CONTINUED FROM PAGE 115.)

The electromotive force in the armature is directly proportional to the variation per unit of time in the number of lines of force passing through the coils. If the armature contain no iron core, we have only to consider the lines of force bridging the pole pieces of field magnets; but if it contain a core we must also consider the lines of force created in it by the armature current itself. We may call the former primary, and the latter secondary lines of force. The part they play in the action of the compound machine is so important that a slight digression into the theory of the Gramme ring will here be necessary.

It is well known that, whilst the ring rotates and sends a current out, the primary lines of force are pulled forward in

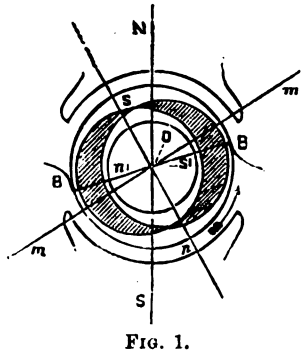

FIG. 1.

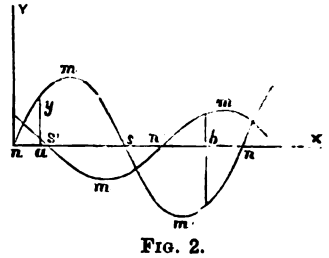

FIG. 2.

the direction of rotation by the curl of the current in the armature wires. Let N O s be the angle by which the field is thus shifted (Fig. 1), then we can consider $s\,n$ a line of symmetry, and imagine that the N pole of field magnet has shifted until it came opposite s, and the S pole until it came opposite n; s and n being the points of greatest polarisation in the Gramme ring. The lines of force divide symmetrically to right and left of $s\,n$. If we were to draw them into the figure we would find that no lines pass the primary poles s and n, but that going to the right or left, line after line, would have to be added until on the diameter $m\,m$ their number becomes a maximum. Graphically, this can be represented by the shaded space, the tangent of inclination between the two curves enclosing that space on any diameter being proportional to the electromotive force which would be created in a coil the moment it passes that diameter. It will be seen that on the diameter $m\,m$ the angle of inclination is *nil*, and, therefore, the brushes ought to be placed in this neighbourhood. Say we place them on the diameter B B. Now, the current traversing the Gramme ring will itself tend to polarise it in the points s' and n'. In many ordinary machines these secondary poles are very much weaker than the primary poles $n\,s$, and their influence can almost be neglected; but in compound machines they become sometimes a source of trouble, and must, therefore, be taken into consideration.

Imagine the Gramme ring cut at n, and spread out into a straight line, then we shall have a diagram for the lines of force something like Fig. 2. This diagram must not be considered drawn to scale; it is not intended to give exact numerical values, but merely to illustrate the idea of primary

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and secondary lines of force. The ordinates of the curve n, m, s, m, n, represent number and sign of primary lines of force along the circumference of the ring n, s, n. As the electromotive force is proportional to the change in that number, it can be geometrically represented by the numerical value of the tangents to the curve, and analytically by the first derived of the ordinates y in regard to the circumference $\left(\frac{dy}{dx}\right)$, supposing the function of the curve itself to be known.

Similarly, we find $s' m' n' m'$ to represent the secondary lines of force, and the E.M.F. actually created in a coil, passing a given point a, can be represented by the combined effect of the two curves. It will be seen that the tangent to the primary curve at that point is positive, whilst that to the secondary curve is negative. In this point the secondary lines oppose, therefore, the action of the primary lines, and the E.M.F. resulting is due to the difference of the two. In point b, however, both tangents are positive, and the resulting E.M.F. is due to the united effect from the two sets of lines of force. A very simple, although, perhaps, not strictly accurate illustration of this can be obtained by applying the parallelogram of forces to represent the intensity of magnetic poles.

Let O s (Fig. 3) represent strength and position of primary pole, O s_1 the same for secondary pole, then O s o will represent strength and position of an imaginary pole, the influence of which is approximately equal to that combined from the two component poles. The brushes B B are necessarily in line with the secondary pole s', and in order to utilise all the E.M.F. available in the ring, the resultant O s o should

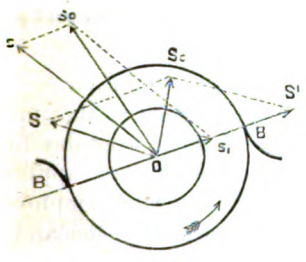

Fig. 3.

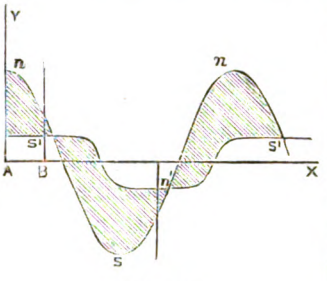

Fig. 4.

be at right angle to O s, that is to say, at right angle to the diameter through the brushes.

Now, suppose in the case of an ordinary shunt machine the external resistance suddenly and considerably decreased. The natural consequence will be an increase of armature current and a decrease of E.M.F at the brushes, which, in its turn, lowers the exciting current and intensity of the field. Unless the field magnets were greatly over-saturated, this reduction in the strength (or, we should say, number) of the primary lines of force will be sensible; and, occurring at the same time as the distorting influence of the armature current is increased, will result in the shifting forward of the primary pole and a reduction in its intensity. Let S be its new position and S_1 that of the new secondary pole. If we now determine the resultant O S o by the diagram of forces, we find that the angle B O S o differs considerably from a right angle, and thus, through the decrease in the external resistance, the brushes have come to be in a wrong position, and, unless adjusted again, will be found to spark heavily.

But, even where no very great variation in resistance takes place, the brushes of ordinary shunt machines are sometimes liable to sparking. The reason seems to be that, owing to there being a finite number of sections in the commutator, the E.M.F. at the brushes is slightly undulating. This gives rise to current-waves in the shunt coils which, under certain conditions (a great number of shunt coils and a weak field), get intensified by a sort of self-induction and cause considerable and quickly recurring variations in the intensity of the field. In consequence of this the brushes are always in the wrong position either one way or the other, and sparking is the result. This difficulty can be overcome by using shunt wire of sufficiently low resistance to get an over-saturated field, or by winding a limited number of main coils over the shunt and thus compounding the machine. The main current seems to exert a steadying influence upon the shunt current, although there are not sufficient main coils to keep the E.M.F. up were the machine accidentally short circuited.

The diagram given in Fig. 2 can be brought into a more convenient form by plotting the numerical values of the tangents to the two curves. We thus obtain Fig. 4.

The distance of any coil from the primary north pole is measured on the horizontal A X, and the corresponding ordinate contained within the shaded space between the two curves gives the E.M.F. of that coil. From this it follows that the area contained between any two ordinates and the two curves gives the aggregate E.M.F. of a group of coils filling the space between these ordinates. The total E.M.F. of the armature will, therefore, be represented by the shaded area contained between the two verticals B B, which represent the brushes.

In computing this area the shaded part between s', B, s, and n' is to be counted positive, that between n and s', and n', n and s', negative. The maximum E.M.F. will be obtained if the position of the brushes corresponds to the points of intersection between the two curves. These points can be found while the machine is at work by the following simple experiment:—Take a fine insulated wire, doubled up so that its two bared ends come to be side by side and about one-eighth of an inch apart. By touching the surface of the commutator with both ends sparks will be observed, the brilliancy of which give some idea of the electromotive force in those coils which correspond to the points touched. Where the brushes touch hardly any sparks at all should be obtained, and if this is found to be otherwise the brushes must be readjusted.

By inserting a voltameter into the circuit of the testing wire sufficiently accurate readings could probably be obtained, by which the curve of E.M.F. could be plotted from actual experiment.

As long as speed and external resistance remain unchanged there can always be found one best position for the brushes. This is the case with ordinary dynamos working always under the same conditions. The secondary lines of force, although present, can always be compensated for by a proper adjustment of brushes.

Not so with compound machines. They have to work under great variations of external resistance and current, necessitating, as was shown in the beginning of this paper, also a certain variation in the electromotive force of armature. If the brushes happen to stand in the best position for one certain current, they will not stand so for a different current, and thus, where the conditions of working are being continually varied, the brushes are, so to speak, continually in the wrong place. It remains to be seen how far this is injurious to the working of the machine and its regulating power. For this purpose we will, by the aid of the diagram (Fig. 4), analyse the action of the machine, assuming, at first, that no current is taken off, and then that a gradually-increasing current is allowed to flow through the external circuit, the resistance of which we assume to be gradually lowered until the maximum current which can be safely permitted has been obtained.

(TO BE CONTINUED.)

Dewsbury Theatre.—The Yorkshire Brush Electric Light and Power Company, of Leeds, are lighting the above theatre by their system of arc lamps. One lamp is erected at the front of the building, one in the auditorium, and one focussing light on the front of the stage. At present the effect is very good for scenic purposes, and the managers are quite satisfied with the result. The company are now fixing two more lamps at the wings on either side of the stage, in order to counteract the shadows cast by the ballet girls from the intense light of the focussing lamp. The dynamo is driven by a small cylinder engine in a turning shop adjoining. The installation is under the supervision of Mr. A. Gay, one of the company's electricians.

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SINCE 1878.

At this season of the year, when the wings of time flap so loudly that we are compelled to hearken; when, much against our inclination, we stand idly watching the flight of a departing year, thoughts arise which, be we never so matter-of-fact, or never so self-complacent, make us serious if not sorrowful, sober if not penitential. We cannot call it back even if we would live the old year over again, and perhaps few of us would like to do that. The pleasures and the triumphs which are fast fading out of sight carry with them also the pains and the disappointments, and these latter we willingly bid good bye to for ever. At any rate, whatever may come of the successes, the failures are all our own, and from the reader's point of view, if not from the writer's, this is much to be thankful for.

In this frame of mind it is natural, perhaps, that we should look back upon the years that have passed since we first made the acquaintance of our ever indulgent readers. That the acquaintance is not of long standing is one ground for satisfaction. So friendly have grown our relations, so helpful and cordial have become our intercourse, that we can hardly believe we first began to know each other less than five years ago. Those years, few as they have been, have served to establish us well in the friendship of our clients; but they have also marked an epoch in the science with which we are all alike deeply interested, and this has made the period seem long, for it has been a most eventful one. Hopeful as we were at starting, we had but a dim perception of what would really come of our venture. We could not foresee that what has happened in the interval would come to pass, nor can we pretend that we hoped it would. But fortune has favoured us all in this matter. Not that we presume to think we have forced fortune's hand; by no means. What we think and say is that fortune's hand was ready, and that we helped her to open it wide.

And, on the whole, we think we are warranted in saying this much of ourselves—that we did assist fortune a little in conferring her bounty on mortals here below; for, if it is true that fortune favours the brave, it follows that fortune has favourites—in other words, that she does not despise instruments, that perhaps without instruments she does not condescend to favour anybody. And in that case we have a claim to be considered an instrument of a very useful sort put into her hand just at the right nick of time.

In the address we put forward at the outset of our career we remarked that the progress of electrical science, the application of scientific discoveries to the wants of everyday life, the extended commercial interests involved in these applications, the importance of the subject to thousands employed in producing or in promoting them, seemed to demand a public journal specially devoted to those interests. Events have proved that our estimate was not mistaken, but the most sanguine of prophets would hardly have predicted how great was the coming need for, and how useful such an organ would be. We were sufficiently modest in our expectations, and they have been more, far more, than realised. At that time, that is to say in the summer of 1878, we were on the eve of great discoveries and the formation of new industries. We saw this, and desired to promote them in every way that a journal could; but, to be modest still, we confess to not seeing how vast would be those industries, how important would be their results.

Just then we were recovering from the astounding discoveries of Professor Graham Bell; the wonderment created by the invention of the telephone was beginning to give place to speculation as to what would be its practical usefulness. A fresh impulse was given to this aspect of the matter by the hardly less curious, if less obviously useful, discovery of the microphone. These discoveries, and many others of a like kind in the electrical world, were, we argued in the address to which we are referring, useless if they remained hidden in the note books of the laboratory, or stowed away in the annals of scientific societies' journals. They must be made public, intelligible, popular, if they were to become useful and were to be applied to the practical purposes of civilisation. There were also the existing industries to be considered—rapidly-growing industries—with enormous capital invested in them already, and absorbing more and more capital every succeeding year. Their successful working, both as regards efficiency and remuneration, was largely dependent on the perfecting of electrical

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appliances—chiefly, of course, of telegraphic instruments. Without these the working of lines at a profit would be impossible, and increased facilities out of the question. Add to this the encouragement needed for original research to further these aims, first by giving widest publicity to its results, secondly by finding a market for its utilisation. Lastly, with a view to the future, we promised ourselves to lend a helping hand to the electrical student, seeing that upon him would depend the final development of applied electrical science. The student, in our view, not only includes the man who makes the study of pure science the aim and object of his life, but also the man who takes the principles to hand and applies them in new combinations to the construction of apparatus designed to ameliorate the conditions of life.

Such, roughly indicated, were some of the objects we had in view. How far we have consistently or successfully followed them must remain with our readers to judge. But about one thing we shall all be agreed—namely, that the four-and-a-half years during which we have been at work have been most encouraging as well as most eventful. The telephone has become a utility as widespread as it is novel; and the microphone, which at first looked like a useless marvel, quickly found its place as a helpmate to its immediate predecessor. Both combined are now playing their part as the indispensable handmaids of commerce and social life. As to the telegraph, it has extended overland as rapidly as we could desire, and under sea perhaps rather faster than we need. But the appliances are keeping well in the wake of the requirements; and, if past experience may guide us in this matter, the increasing means now at our command to dispose of telegraphic traffic will largely help to swell it, and give to enterprise its reward. Duplex and quadruplex telegraphy applied to submarine cables have more than paid their discoverers, and in due time will amply repay their patrons.

There was one other subject we had in our minds, though we did not make much of it at the time. The electric light was just then beginning to make itself known for ordinary public purposes, but only beginning. How few and insignificant were the improvements then accomplished is evident from our pages at that date. For a long time the patents relating to electric lighting did not constitute more than five per cent. of our weekly summaries of recent inventions. Now they are, probably, nearer fifty per cent. Nevertheless sufficient progress had been made to show that in a comparatively short time a formidable rival would make its way in public favour to the old-established gas lighting agency. How short that time would be we certainly did not anticipate, but in this we were not singular. If anybody else was wise enough to foretell its extraordinary and unprecedented development in the course of three or four years, all we can say is that we have ungrudgingly helped to make his prophesy come true. The practicability of the electric light is now fully established; its popularity is well assured; all that remains is for scientists and experimentalists to render it tolerably cheap. From week to week our pages testify to the efforts being made in this direction, and when another new year comes round we doubt not that the record of substantial progress will be as gratifying as it has been in the last. Those birds of time who are flying away with all that we have done, scattering our departed selves on the revolving age below, are followed by others not slower on the wing, but also not less indulgent. They will have the happiest new year who, seizing the fleeting opportunities, are fortunate in doing something worth leaving behind them on the ages yet to come. May fortune so favour all our kind friends.

DANGERS TO ELECTRIC LIGHTING.

(FROM A CORRESPONDENT.)

One frequently meets with paragraphs in the non-technical press concerning the—for the most part visionary—dangers *from* electric lighting, but our theme is the converse of this—the dangers *to* electric lighting. These come about in various ways, one of which is this same ignorant writing we have just referred to, which tends to scare would-be users, the class especially, and it must, after all, be the class composing the majority of those who will ultimately adopt the light, which only cares for the resultant light and its cost, not heeding the way or means of its production. How many out of the millions using gas know the details of gas making? But neither is our theme with this danger. The danger we would draw our readers' attention to is a danger from within, and we have reason to know it is a very real one. It arises from the desire of certain companies and individuals to do immediate business at any cost, with the result, as the head of a large firm said to us the other day, "I'm sick of the whole thing, and have given orders to have the whole plant cleared out at the end of the week." What has brought this undesirable state of things about it may be instructive to examine into a little more fully. The case we refer to is in every respect a typical one, and had success attended the installation a large business was assured to the company. As it is, gas is again in the ascendant, and, as far as the company referred to is concerned, a whole district had better have been omitted from the map of Britain. Without indicating the locality suffice it to say that we, a few weeks since, chronicled the fact of the starting of electric lights in an extensive weaving mill. For a few days all seemed promising—a few lamps were broken certainly, but this was thought little of for a start, and a single dynamo was used, driven by a countershaft from the large mill engines. On our next visit we were not surprised to find that this dynamo had altogether vanished, it was never cool enough to touch, and two of quite a different type had been substituted, with but small improvement. The company's electrician declared the speeding was at fault, but as he had had absolutely every thing under his own control from the beginning the fault lay with him. The speed was altered, still lamps broke. This breakage might have even been tolerated, for the light, when good as it was occasionally, was a great advance on gas. But now arose the difficulty of keeping the dynamos running long enough continuously, for nightwork is the rule and not the exception in this mill at certain seasons. We were told that a set of brushes hardly lasted for an ordinary run, that the armature where it is in contact with the brushes is hopelessly cut and scored, so that sparking is continuous. On our several visits to the mill we have generally been lost in wonder at the way things were managed by the Electric Light Company in marked distinction to every other department. It will hardly be believed that in what was avowedly a test installation—an installation at the company's own request—there was not a single instrument for measuring current or illuminating power of lamps, even in the roughest way; the leads simply went direct from the dynamo to the departments where the light was used. We have no idea why the lamps broke, for we know nothing of the strength of current, E.M.F., or anything else. We had our suspicions all along, and we greatly regret that they have now been fully confirmed. That the lamps were faultless is not to be supposed, for it was manifest that their resistances, as they broke in all parts of the circuit, were far from uniform. This could be seen without the breakage test, which was too frequently involuntarily made. We have gone thus fully into one particular case rather than give instances from various districts, but we are sure they could easily be supplied, and would form instructive reading.

SOUTH AFRICAN TELEGRAPHS.—The revenue derived by Cape Colony during last October from telegraphs was £4,427 14s. 9d., against £5,603 6s. 1d. in the same month of 1881, or a decrease of £1,175 11s. 4d.

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MR. STAITE'S IMPROVED APPARATUS FOR LIGHTING BY ELECTRICITY—1847.

It is well known that Mr. Staite was one of the first inventors in the field of electric lighting, and it is interesting to know how his ideas compare with those of to-day. His form of lamp is very little known, hence we do not hesitate to reprint the following description from an old volume of the *Mechanic's Magazine*:—

Fig. 1, is an external elevation of the apparatus; fig. 2, a sectional elevation of it on the line, W *x* (fig. 3); and fig. 3, a horizontal plan on the line, *y z* (fig. 1). Mr. Staite's description is as follows:

M, and N, are two cylinders of carbon prepared as is afterwards described, which are used as the electrodes, that is to say the current of electricity is passed from one to the other as they stand end to end, their ends being separated by an interval of from less than one-twentieth to about half an inch, according to the power of the electric current used. The upper electrode, N, is passed vertically through a hole in the summit of the metallic support, or tripod, K, and fixed by binding screws. The lower ends of the legs of the tripod are passed through holes in the circular main-plate, A, of the apparatus, and secured in their positions by collars and nuts, but are carefully prevented from coming into metallic contact with the plate, A, by means of washers of some dry, hard non-conducting wood. The legs terminate at bottom in set screws, L L, which connect them with a conducting wire, which passes round through the extremities of all the legs, and is connected with one end of the coil of the regulator, *r*. The other end of this coil is led to a clamp, R^2, with a set screw fixed at one side of the square wooden basement, B, on which the whole of the apparatus is built, and which is mounted on four short supports, *b*, *b*, *b*, *b*, at its corners, to allow room for some parts of the apparatus which project below the basement. The main plate, A, is firmly attached to the basement, B, by four pillars, *c*, *c*, *c*, *c*; C, and D, are cones which spring from opposite sides of the apparatus, their common axis passing at right angles through the centre of the main-plate, A, which is bored out for the purpose. The apices of these cones are perforated, to admit the perpendicular central shaft, O, which has a socket for receiving and holding the lower electrode, M, at its upper end; and this socket is furnished with set screws for securing the electrode in an upright position in its centre, even though that electrode should happen

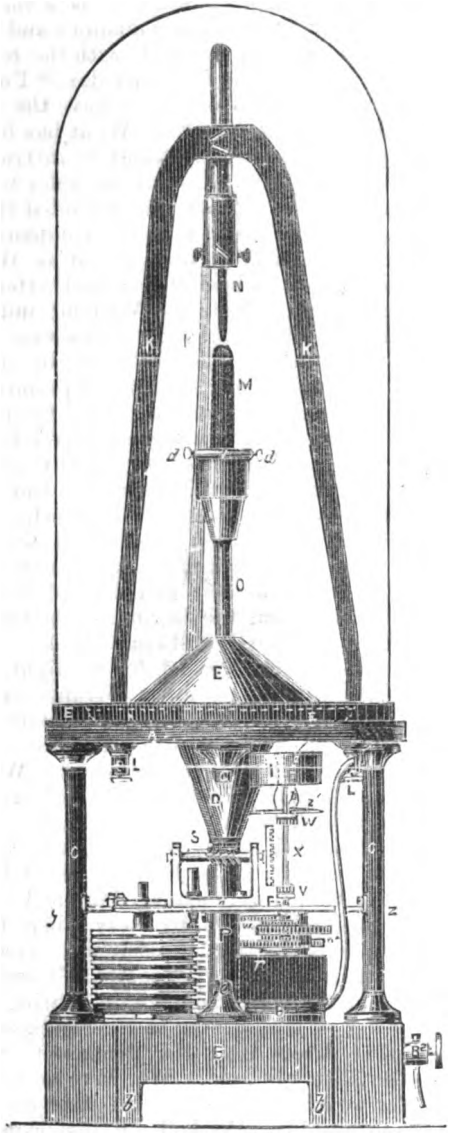

Fig. 1.

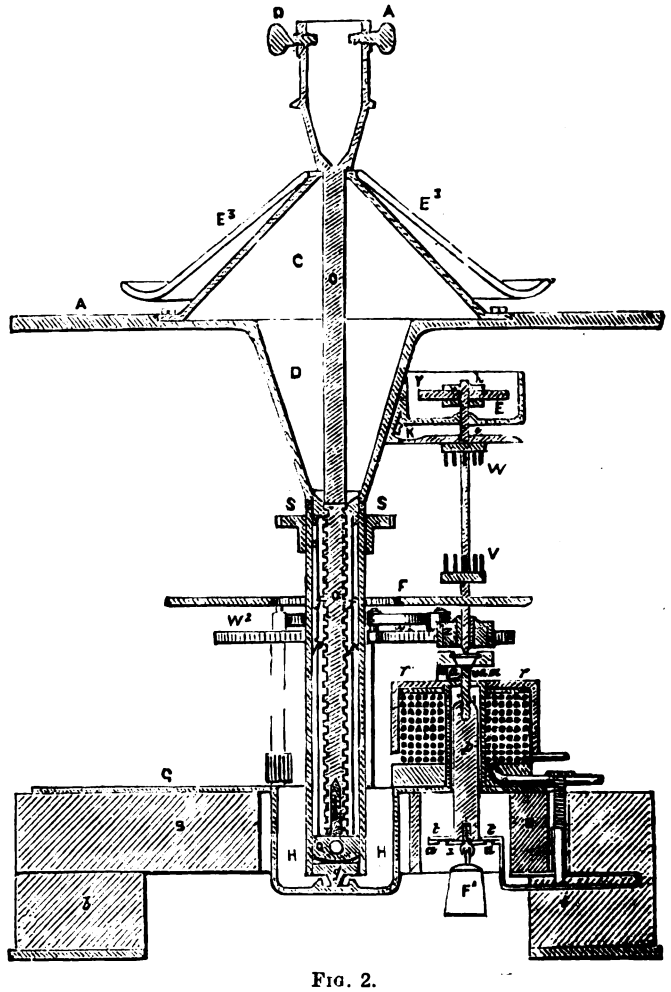

Fig. 2.

to be of smaller size than the socket. At the bottom the socket is made of a conical form, in order to keep the lower end of the electrode steady and concentric, so that it may be properly adjusted by set screws, *d*, *d*. This shaft, O, has a smooth straight part, below its socket, for a length equal to the distance between the apices of the fixed cones, C, and D, which is equal to the amount of rise which the shaft admits of, to compensate for the wear or shortening of one of the electrodes, while the light is in action; this smooth part of the shaft moving freely through the hole in the apex of the upper cone. Below this smooth part the shaft is continued for an equal length, screwed; the threads of the screw giving about one-twelfth of an inch of rise for every turn. This screwed part works through a nut, *e*, which is set tight in the apex of the under cone, D, and passes down the centre of a hollow cylinder or tube, P, which is slotted internally (as shown at *f*, *f*, in figs 2 and 3). A little cross piece of metal, Q, is set tight on the bottom of the shaft, O, by being screwed

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fast into its end, and this cross-piece, Q, (which is more particularly described in Fig. 4) fits across the tube, P, taking into the slots or grooves on each side, so that it can slide up or down in them. When, therefore, the tube, P, is made to revolve, it carries the shaft, O, round with it, by means of the sliding cross-piece, Q, and makes it to rise or sink by its screw working in the fixed nut, *e*, so that the shaft, O, carrying the electrode, M, in its socket, has a rotary motion combined with its vertical motion for the purpose of equalising the wear of the electrodes on all sides. The tube, P, turns on a pivot, *g*, which works in the bottom of a circular box of metal, H, which is screwed into a hole of sufficient size in the bottom of the brass-plate, G, which is fixed to the upper surface of the wooden basement, B. The touching surfaces at the pivot, *g*, are coated with silver; as that metal presents a surface peculiarly fitted for receiving the current of electricity. The upper end of the tube, P, receives the outer part of the fixed nut, *e*, on which the outer tube turns, and is steadied as on an axis. On the upper part of the tube, P, a worm-wheel, S, carrying forty teeth, is attached, which is made to revolve by a horizontal double-threaded tangent-screw, T, the pitch radius of which is one-tenth of an inch. To one end of the screw is attached a crown-wheel, U, carrying forty teeth, which is actuated by pinions, V and W, on an upright spindle, X. The pinions are at a somewhat greater distance apart than the diameter of the crown wheel, U, and gear into it from opposite sides, so that when the spindle, X, is raised a little, the lower pinion, V, (having eight teeth,) is geared into the lower side of the crown wheel; but when the spindle is sunk, the lower pinion is thrown out of gear, and the upper pinion, W, gears into the upper side of the crown wheel; and the spindle continuing to revolve in the same direction as before, imparts a reversed rotation to the crown wheel. When the spindle is kept at a medium degree of elevation, neither of the pinions is in gear with the crown wheel, so that it remains quiescent. This spindle, X, is kept in its position by working through a hole in the middle plate, F, of the apparatus, which plate is attached firmly to three of the pillars, *c*. The upper end of the spindle works through a hole in the centre of the bottom of a circular brass box, I, which is fixed to the side of the under cone, D, or to the under side of the main plate, A. The box, I, contains a centrifugal regulator, Y, which consists of a bit of watch-spring bent into the form of the letter S, carrying two little weights, *hh*, at its ends, and fixed horizontally across the top of the spindle by the middle part of the spring, which fits into a cleft in the top of the spindle, and is secured by a small nut. When the spindle is made to revolve too fast, the weights at the end of the spring fly outwards by their centrifugal force, and begin to touch and rub against the sides of the circular box, I, which friction checks the motion. This description of governor preserves the motion more uniformly than the ordinary sort of fly, which acts by the resistance of the air. Just below this centrifugal governor there is a cross-piece, *i*, inserted through a transverse hole in the spindle, X, so that when the spindle is as its medium degree of elevation, that is to say, when its two pinions, V and W, are neither of them in gear with the crown wheel, the ends of the cross-piece, *i*, meet a stop, K, which may project from any fixed part of the apparatus, such as the cone, D, and so stop the revolutions of the spindle; while, as soon as the spindle is raised or lowered, the cross-piece, *i*, no longer meets the stop K, but passes over or under it, and allows the spindle to commence its revolutions just before one of the pinions gears into the crown wheel. The spindle, X, is actuated and kept with a constant tendency to revolve in one direction by a toothed wheel, Z, keyed on to it just below the middle plate, F, and this wheel is driven by a train of wheelwork, W^2, supported between the middle and bottom plates, F and G, similar to ordinary clockwork, and which is driven by a spring in a barrel, *l*, acting on a fusee, *m*, driven by a cord or chain; or the wheelwork may have any other contrivance as its prime mover, as, for instance, a common barrel with a cord and weight. The wheel, Z, is of such thickness that the motion up and down, which the spindle X admits of, will not ungear it from the next wheel in the driving train.

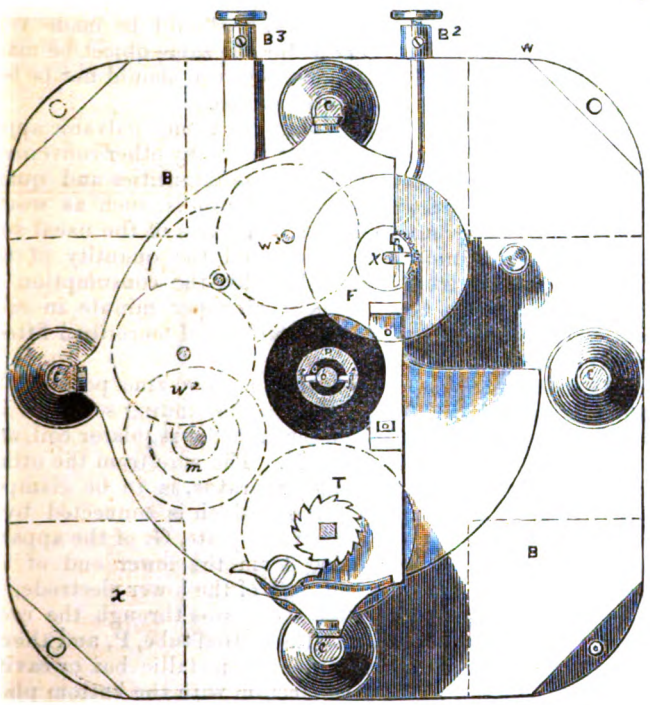

FIG. 3.

The mode in which the spindle, X, and its pinions are raised or lowered, so as to drive, or stop, or reverse, the motion of the crown wheel, U, and thereby of the electrode, M, according to the exigencies of the light (as, for instance, when the electrode becomes worn, or any alteration takes place in the power of the battery,) is exceedingly ingenious, and is as follows:

FIG. 4.

The bottom of the spindle terminates just below the driving wheel, Z, and rests on a plate of ivory, *n*, which is supported on a short upright stem of brass, *o*, which has its lower end screwed into a hole in the top of a solid cylinder of soft iron, *p*. This iron can move freely up and down in the central hole of a reel, *q*, round which a quantity of insulated copper wire is wound: one end of this wire is led to the binding screw, B, as before mentioned, which connects it with the positive wire of the galvanic generators, and the other end to the wire which passes through the binding screws, L. The reel, *q*, of the regulator is fixed firmly to the wooden basement, B, and a cap, *r*, of soft iron, fits over it; but the iron of the cap does not extend quite to the centre of the hole in it (through which the brass stem, *o*, passes), the central part of the top of the cap being of brass soldered to the iron, of one-half of the diameter of the iron cap itself. The action of the electricity in the coil of the regulator, R, causes the iron centre, *p*, to rise or fall, according to the quantity of electricity passing, and in so doing, the spindle, X, which rests on it, to rise or fall with it. There isa little eye attached to the bottom of the iron centre, to which is suspended a counterpoise, F^1 (an assortment of such counterpoises being kept for use), of such weight as to allow the iron centre to be just in equilibrium, or just ready to rise, when the distance between the electrodes is such as to allow the electric current to flow freely enough to produce a steady and certain

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light. There is also a little ledge, *s*, around the lower end of the iron centre, on which rests a disc, *t*, of brass, of about the size indicated in the drawing, fig. 2; which (when the iron centre falls below the neutral point) becomes supported around its outer edge by a circle of brass, *u*, and is left behind on it, when the iron centre continues to descend, thus relieving it of its weight; while on the other hand, if the iron centre is disposed to rise above the neutral point, it has to lift the whole weight of the brass disc, *t*. This arrangement gives the iron centre a tendency to remain stationary at the neutral point, which is that point at which the elevation of the spindle, X, enables the cross arm, *i*, to come into contact with the stop, *k*, and arrest the rotation, and so prevent unnecessary working of the machinery, until the electric current has varied so much as to render desirable an adjustment of the distance between the electrodes; which the iron centre effects, as before described, by rising or falling.

The neutral position at which the iron centre, *p*, should rest, is when the top of the iron centre is as far below the top of the regulator reel as is represented in figure 2.

The brass ring, *u*, which supports the equilibrium weight, that is the brass disc, *t*, is secured at the proper height by being attached to a sufficiently stiff strip of brass, *w*, of a certain length, and which is fixed by its other end to the other side of the wooden basement, B. The brass ring, *u*, can be adjusted to the requisite height exactly, after the apparatus is made, by a milled-headed screw passing through the wooden basement, and screwing down on the supporting brass strip (not far from *u*), so as to depress it to the right position.

The sliding cross-piece, Q, before adverted to, is constructed in the manner separately represented in fig. 4. A spring, Q, (of thin hard brass, for instance,) is attached to one side of the cross part by a small screw, so that when the cross-piece is placed in the slots of the tube, P, the spring always remains in close though not forcible contact, against the sides of the slots, so as to ensure a good conduction to the electric current which has to traverse the shaft, and enter from the cross piece into the slotted tube.

The tangent-screw, T, is made not quite horizontal, but inclined at an angle of one in twenty, because the lower pinion, V, is smaller than the upper one; and therefore it is necessary that the lower edge of the crown-wheel, U, should be tilted nearer to the axis of the spindle, X. The lower pinion is made smaller, in order that it may the better wind down the main shaft, O, after it has screwed itself up, until the ends of the electrodes come into firm contact, lest it should stick in that position.

The screw, No. 1, which fastens the stand, 3, of the tangent-screw to the middle plate, F, passes through a hole, 4, enlarged sideways in the stand; so that by only loosening the screw, 1, the stand may turn on the other screw, 2, as a centre, so as to allow of the tangent-screw, T, being adjusted to the right distance from the centre of the wheel, S, in order that it may work properly into its teeth, or, when required, to throw the tangent-screw out of gear with it altogether.

The thread of the screw of the main shaft, O, should be of a square form, so that it shall work with as little friction as may be, when supporting the weight of the shaft and electrode.

A cone of white glass or porcelain, E^3, is made to slip over the upper cone, C, of the main plate, and is turned up at the edges (as shown in figs. 1 and 2), to reflect the light better, and to catch any dust and ash which may be thrown off from the electrodes.

A glass shade, which may be ground partially or not, as desired, fits over the electrodes, M and N, and the stand, K, and is screwed down to the main-plate, A, by the brass circle, E, into which its lower edge is cemented, whereby the electrodes are enclosed entirely from the outer air. As soon as they have exhausted the oxygen which is within the glass shade, they are no longer so rapidly consumed. When the electrodes, however, are composed of some inferior sorts of carbonaceous preparations they give light more steadily if a very small quantity of atmospheric air is continually allowed to enter; that is to say, just sufficient to burn away the button of carbon which sometimes forms on the end of that electrode which is not undergoing decomposition by the electric current. When there are no holes in the glass shade to admit of a small quantity of atmospheric air, two light valves may be inserted in the main plate, A, one opening inwards and the other outwards, which would provide for the varying pressure of the air when the temperature is altered by the presence or absence of the light within.

The coil of insulated wire of the regulator, R, should be composed of wire of such thickness as to conduct the electric current quite freely. For an apparatus of the size represented in the engravings it may be about three-sixteenths of an inch in diameter; but if electrodes of a larger size are employed, the wire should be proportionally increased in thickness, and the regulator, R, made as large as the dimensions of the apparatus will admit of, in order that the reel should take a sufficient number of turns of the thick wire; for with wires too thin, considerable heat is evolved from them when transmitting the current. Two circular brass weights, *a a*, fit one over the other around the ivory top, *n n*, which carries the pivot of the spindle, X; their use is to enable an easier and more precise adjustment of the weight on the iron centre than can be effected by altering the large weight, F^1, which is hung at the bottom of the iron centre.

When it is intended to use small currents of electicity, the spindle, X, and all its appurtenances, should be made very light, and the iron centre may for the same object be made hollow with advantage; its sides, however, should not be less than one-twelfth of an inch in thickness.

The electric current may be obtained from a galvanic apparatus of any of the known sorts, or from any other convenient source; and it may be used of various intensities and quantities. A good degree of intensity to use, is such as would be afforded by one hundred cells in a series of the usual sort employed in galvanic apparatuses; and the quantity of the current may vary from that evolved by the consumption of less than one and a half grains of zinc per minute in each cell, to that evolved by the consumption of more than fifteen grains of zinc per minute.

The wire from the positive, that is, the zinc pole of the galvanic apparatus, is clamped with the binding screw at B^2, which serves as the conductor through the regulator coil, and then up to the upper electrode, N. The wire from the other, or negative pole of the galvanic apparatus, is to be clamped with the other binding screw at B^3, which is connected by a slip of metal (copper) to the bottom plate, G, of the apparatus, so that the current passing from the lower end of the upper electrode, N, to the top end of the lower electrode, M, then traverses the central shaft, O, passes through the cross piece, Q, at its lower end, into the slotted tube, P, and thence through its pivot at bottom into the metallic box or cavity, H, which being in metallic connection with the bottom plate, G, leads the current to that plate and thence by the slip of copper to the other clamp, from which it passes in return circuit through the negative wire of the galvanic apparatus. The current, when first applied with the electrodes in contact, flows freely, and that causes the regulator (being properly weighted) to raise the spindle, X, and thus put the apparatus into gear for screwing the centre shaft, O, downwards, and gradually separating the electrodes, whereupon the light begins to appear between them.

Mr. Staite specifies, also, as included under his present patent, the following method of preparing the carbon for his electrodes:

About equal quantities are taken of coal of a medium quality, and of the prepared coke, known as "Church's Patent Coke," and both reduced to a state of fine powder and intimately mixed together. The mixture is then placed in close wrought iron moulds, which may be made either to give the mixture the form of a block, to be afterwards cut into pieces of the required shape, or to give at once to the mixture the form of the intended electrode. In all cases I prefer making the moulded mass of not more than 3 or 4 inches in its least diameter, for when much larger it is liable to have fissures, and not to be of such uniform density. The mixture being placed in these moulds, is subjected to heat and heavy pressure until it becomes consolidated into a very dense and firm mass. And when the mass is in a heated state it is

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plunged into sugar, melted by heat (without the aid of any liquid,) and kept therein for a short period. It is then taken out and allowed to become cold, when it is placed amongst pieces of charcoal in a close vessel, which is gradually heated until it attains a full red heat, after which the temperature is increased to an intense white heat; at which it should be kept for many hours, or even two or three days, according to the hardness and compactness desired. Or the mass may be a second time immersed in the melted sugar while hot, and the remainder of the process be again repeated as before.

By coating the mass in this way with melted sugar, any pores that may be in it (on its external surface at least), are filled up with carbonaceous matter, and any subsequent drying rendered unnecessary.

However, Mr. Staite limits his claim as to this method to the application of *melted sugar*. A solution of sugar *and water* has, we believe, been before used for the same purpose.

The following are stated to be the best dimensions for the electrodes:

The lower electrode should be as long as can be conveniently manufactured (8 inches, for instance,) when used for ordinary purposes, and it should be of a cylindrical form. The smaller the diameter is the better the light; but the larger the electrode is (in cross section) the longer it will last with a given current of electricity. The upper electrode need not be of any great length; it is well, however, to have it about one-third as long as the lower one, and of half the diameter.

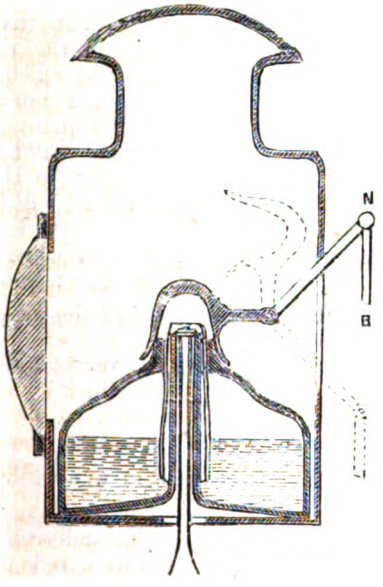

FIG. 5.

Mr. Staite concludes his specification with the following account of a method of employing currents of electricity "to actuate apparatus for effecting the speedy lighting up and extinction or obscuration of signal lamps in which oil, camphine, or other like inflammable fluid is the illuminating substance employed."

Suppose, for example, there are three such lamps with different coloured glasses, say white, green, and red, which are required to be sometimes lighted, and at other times extinguished or obscured, as is usual on railways, and not all at once, but in a particular order of sequence, or each under particular circumstances only, I effect this in the following manner:—The three coloured signal lamps are placed side by side, or they may be placed one above the other. A sectional elevation of one of these lamps is given in fig. 5. N is a bar of metal, having a drop bar, B, attached to it. These bars are for the purpose of working three extinguishers, one to each lamp. The figure shows one of these extinguishers as applied to a lamp; the dotted lines in the figure indicate the position which it assumes when raised up. The drop bar, B, is attached to a clockwork escapement, the detent of which is alternately retained and liberated by the passage of an electric current, and by its mechanical force raises up the bar, B, and causes the light, in whichever lamp it may be, to be put out. The three extinguishers are made to move together, to save the necessity of each being provided with a separate extinguishing mechanism. In the centre of the burner of each lamp is a small ring of fine platinum wire, which is so contrived as to touch the wick of the lamp, and the current of electricity being made to pass through this platinum ring, it becomes intensely heated, and thereby ignites the wick of the lamp. I do not restrict myself, however, to the employment of platinum wire, as carbon for this purpose may be used, or any other difficultly fusible material; neither do I limit myself to the employment of a ring of any particular form. The wick may, for instance, be a flat wick, and in that case a straight piece of wire would be suitable for the arrangement.

How the wires from the battery are connected in the last arrangement with the lamps and the escapement, Mr. Staite considers it unnecessary to describe, "as the mode of doing so must be obvious to all who are familiar with the subject of electricity." "It may be sufficient," he adds, "to state, that one wire for the return current will be sufficient for the whole series of lamps and the mechanism connected therewith."

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are alternative solutions to some of the earlier questions in the paper hitherto considered, by E. C. RIMINGTON, ESQ. (School of Electrical Engineering), 12, Princes-street, Regent-street.

1. Explain fully why, at the present day, it is more economical to light large rooms with the electric light than with gas, and why this was not the case some few years back.

Ans. For lighting large rooms we can employ arc lamps, from which we can obtain, as an average, 1,500 candle-power per h.-p. indicated.

Now, in the average engines, one h.-p. can be obtained by the consumption of 2½lb. of coal per hour, and, in some of the more improved ones, of less than 2lb. An ordinary gas burner, with the best gas, gives a light of 30 candles per 5 cubic feet consumed per hour. About 11·3 cubic feet of gas are obtained from the destructive distillation of 2½lb. of coal. Therefore, 1,500 candle-power require 4·42lb. of coal in the shape of gas, which makes the electric light for large rooms nearly half the price of gas as regards the quantity of coal consumed.

Even in using the incandescent system as at present, where the average candle-power is only about 300 per h.-p., we must remember that the air is not contaminated by the products of combustion as in the case of gas; there also being no smoke, there will be consequently a great saving of whitewash. In libraries it will be specially useful, as it is an undisputed fact that gas destroys the backs and covers of all leather-bound books exposed to its influence.

3. Explain fully, with sketches, how dynamo machines of the Brush type differ from those of the Gramme? What are the relative advantages and disadvantages of direct and alternate current dynamos?

Ans. As regards the internal arrangement, in the Gramme dynamo no coils are cut out at any period of the revolution, but the current flows through all of them, while in the Brush machine each pair of coils, as it passes the neutral point of the field, and is therefore incapable of doing work, is cut out of the circuit.

The advantage of an alternating current dynamo compared with a direct current dynamo is that in the former no commutator is required, which renders the construction of the machine much simpler, its disadvantage being that the iron, if any, forming the cores of the field magnets is more liable to become heated through its rapid magnetisation and demagnetisation. An alternating current machine has also the disadvantage that it cannot be employed to charge accumulators, as in the case of a direct current machine. It is said, however, that incandescent lamps

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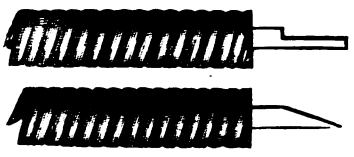
lighted by an alternating current, have a longer life than when a direct current is employed to illuminate them.

4. A joint has to be made between the ends of two thick electric light wires. Explain, and give sketches of, the method of jointing you would employ. In carrying wires, between which there is an electromotive force of 300 volts, through the rooms of a building, what method of insulation would you make use of? Show exactly how you would lead wires to a number of incandescent lamps suspended from a bronze chandelier, and give the reasons for adopting your method.

Ans. Strip the ends of the cables to be joined for two or three inches, solder together the separate strands into a solid mass capable of being easily filed, file the ends of each to one of the accompanying forms. Fit them together, bind with a piece of fine wire, say No. 26 B.W.G.; run solder into the joint thus formed, finally insulate the joint with some insulating compound, and wrap round with tarred tape. In carrying wires having an E.M.F. of 300 volts between them they should, where it is possible, be carried along on opposite walls of the rooms. If this is impracticable they should be run at a distance of, at least, 12 inches from one another; and, if at any point it is absolutely necessary to cross the wires, one of them should have a piece of wood, cut with a notch to receive the wire, fastened over it, and the other laid over the top of this piece of wood. The wires should themselves be well insulated with tarred tape or other insulating compound. Wires insulated with a mixture of paraffin and colophane or resin, and then encased in a piping of lead, as manufactured by MM. Berthoud and Borel, are exceedingly useful for this kind of work. The suggestion given by Mr. Massey, of the Electric Light and Power Generator Company, that the leading should be placed to the left or lower, and the return wire to the right or higher, might also be advantageously followed.



In leading wires to a number of incandescent lamps suspended from a bronze chandelier, one of the terminals of each lamp should be connected to the chandelier; the other to a well-insulated wire, the wires being run through the stem of the chandelier.

A few notes on some of the questions may guide students where to look for information.

Question 11 deals with photometry, an important but little studied subject. Brief accounts will be found in Watt's "Dict. of Chemistry," vol. iii., p. 597, in "Deschanel," 6th edition, p. 963, in Thresh's "Physics," p. 161, in Ganot's "Physics," &c., in fact, the ordinary methods are to be found in almost any book on Light, or Physics. Specific information, however, is perhaps only to be obtained from various papers by Professor Tyndall, Professor Ayrton, Dr. Siemens, Mr. Sugg, &c. The greatest mistake students make is to rely upon text books for information. The text book must, as a rule, be a year or two—it may be, more—behind the times, and it is only by constant reading of technical journals and the *Proceedings* of learned societies that one can hope to keep abreast with progress.

Question 14, referring to the transmission of power by electricity, is a case to the point. So far as we know, only one book has been published which deals with this question, that of Dr. Paget Higgs, issued by Messrs. Spon in 1879. But a good deal of attention has been given to the subject since 1879, and it is just now attracting more attention than ever. We think we are justified in saying that students should study this subject, as presenting one of the greatest fields for original investigation. Besides our own paper, we would refer to *La Lumière Electrique*, *Comptes Rendus*, the various papers of M. Deprez, and his critics. We plead ignorance of Frölich's work, which, as yet, has not an English dress, though we may mention here that Schellen's "Magnet und Dynamo-Electrischen Maschinen" is about to be published by Messrs. Van Nostrand and Co. in America.

To be Wound Up.—A petition for winding up the Phœnix Electric Light and Power Company has been presented to the High Court of Justice.

CORRESPONDENCE.

STATIC ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In an article entitled "The Inductive and Conductive Circuits," at page 128 of this volume, Mr. J. T. Sprague begins with the extraordinary assertion—there is no such thing as a *quantity of static electricity*. The first reason which he gives for making this statement is that the practical unit of electrical quantity, the coulomb, is independent of the actual nature of electricity, and is simply measured by certain results of electrical action. His second reason is exactly of the same kind, for here he maintains that "that quantity of electricity which, placed at unit distance from an equal similar quantity, repels it with unit force, is not a quantity of electricity, but of force."

In both cases he loses sight of the distinction between a quantity and the measurement of that quantity.

For example, the unit of force is defined to be the force which produces unit of momentum in unit of time. Will Mr. Sprague, therefore, assert that there is no such thing as a quantity of force?

Mr. Sprague finally explains that by static electricity he means potential energy, and by dynamic electricity he means kinetic energy, and by combining this with Mr. Sprague's statement that there is no such thing as a quantity of static electricity, the result obtained is there is no such thing as a quantity of potential energy, but that quantity of energy can only have a meaning in the case of kinetic energy. With regard to any statement which would require electricity to be a form of energy, I must remind Mr. Sprague that if in any given time a quantity, Q, of electricity pass through a linear conductor along which a constant electromotive force, E, is acting in the direction of flow, the work W done in the given time will be E Q.

Thus the amount of energy expended is E Q, and as E is not a quantity of zero dimensions, or mere number independent of the units employed, it follows that Q or $\frac{W}{E}$ cannot possibly be an expression for energy.—Yours, &c.,

G. W. Von Tunzelmann.

"GLOW" LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Dr. Siemens in a recent lecture suggested the term "glow" lamp in preference to "incandescence" lamp; and I observe that Mr. Preece has accepted the innovation, which, he states in a recent lecture to the Society of Arts, to be equally correct and more euphonious than "incandescence," while being also more in accordance with the spirit of the age. The present tendency is certainly towards brevity of expression in English; but accuracy ought not to be sacrificed to mere brevity, and, with due deference to Mr. Preece, I think it can be shown that "glow" is not so correct as "incandescence." A glow can be produced in a variety of ways, but incandescence only in one way. We have the glow of burning phosphorus, of luminous paint, of the *glow*-worm spark, of the aurora, of the "gloaming" sky, of the Alpine heights after the sun has set (the after-glow); but incandescence is only produced by heating up a solid body until it emits light. To give out white light, its temperature ought, as is well-known, to be roughly 1,000° F. Therefore, the carbon filament lamp is very properly an "incandescence," and less properly a "glow" lamp.—Yours, &c.,

J. Munro.

2, Somerset-villas, West Croydon, December 27.

CROMPTON'S COMPOUND MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I can hardly be expected to answer the vigorous, not to say violent, personal attack contained in one of the letters

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on this subject you published in your last issue, for such correspondence, besides being uninteresting to the public, is always undignified, and particularly so when by a slight admixture of technical matters it manages to creep into the columns of a high-class scientific journal. By the tone of the letters one might be led to believe that not only was compounding an old idea (which I never denied), but also that compound machines have been a regular article in the market since the spring of 1881. As it would be very interesting to have this point cleared up, will you or any of your readers kindly state where compound machines of other than Messrs. Crompton's manufacture, and of previous make, can be seen at work in England?—Yours, &c.,

Chelmsford, December 27, 1882. GISBERT KAPP.

SECONDARY BATTERIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to your correspondent, Mr. B. Unwin, I am happy to supply any particulars relating to the application of secondary batteries to arc lighting.

The Sellon-Volckmar accumulators which were shown at my lecture at Limehouse were of the one horse-power type, capable of furnishing a current of 20 amperes for 15 hours, or 30 amperes for 10 hours; in other words, their capabilities may be expressed by 300 amperes-hours.

Since this accumulator adapts itself to any requirements for high or low currents, it is necessary that the circuit should be properly arranged.

An arc lamp, to work with accumulators, must be accurately adjusted, the carbons must be fed gradually, and not by sudden jerks.

The accumulator in question is capable of giving a current of over 100 amperes for a short time, and this current would work great mischief in some lamp-fittings if allowed to flow at that rate; thus, if the carbon-rods were to touch each other, there would be a tendency for the current to make the carbons incandescent throughout their whole length, and the result would be a rapid discharge of the accumulators, and great diminution of light.

Until a new arc lamp is devised in which the carbons are prevented from touching each other, it will be necessary to insert such a resistance in circuit as will prevent a too powerful flow of current, and this latter method I adopted with the Pilsen lamp, which gave a perfectly steady light with 10 amperes and 56 volts.—Yours, &c.,

A. RECKENZAUN.

Poplar, December 27, 1882.

THE AURORA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I read your amusing editorial on the 8 h.-p. electric light at Milwaukee, illuminated by the aurora.

The facts were simply that an Edison incandescent lamp was attached to one of the St. Paul, Western Union, Telegraph wires, with the other side to earth. It is an 8-candle lamp, requiring about $\frac{1}{8}$ h.-p. to illuminate it, not 8 h.-p. The auroral current developed about half the capacity of the lamp, using probably $\frac{1}{16}$ h.-p.

The agent of the Associated Press was unduly excited at New York, and so it went through the cable to your papers as 8 h.-p.—another illustration of the depth of scientific knowledge possessed by newspaper men.—Yours, &c.,

C. H. HASKINS.

IS THE MICROPHONIC CONTACT AN "ARC?"

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I committed an error in my last letter in saying electromotive force of "2 volts of a Leclanché cell." This, of course, should be 1·4.—Yours, &c., E. BERLINER.

The American Bell Telephone Company, 95, Milk-street, Boston, U.S.A., Dec. 9.

ELECTRIC REPULSION—III.

BY J. T. SPRAGUE.

In two previous papers I have shown that apparent repulsions belong to two orders of cause: 1, to the transfer of motion from one body to another; 2, to the sum of the actions of a "field of force." This latter process is so readily traceable in the mutual action of magnets, that it seems preferable to study the action there rather than in the electric field of force, which is by no means so easy to trace out. The appearance of an active repulsive force is also more strong in the case of magnetism than in any other, because not only is there no attraction between like magnetic poles, unless one is strong enough to overpower the other, but they do seek to avoid each other, and no apparent source of attraction exists in the opposite direction. If, therefore, repulsion and repulsive force are negatived in the case of magnetism, the argument in favour of their existence is greatly weakened. This having been accomplished, it is a simple matter to deal with electric repulsion proper.

Two bodies *similarly electrified repel each other.*

When two pith balls hanging side by side are electrified from the same source, they separate, and appear disinclined to come together.

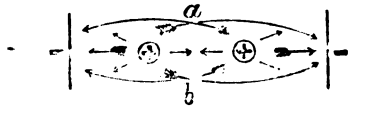
When an electric is rubbed it attracts light bodies, and then repels them.

Let us examine the last statement first; and, first, let us inquire, although it is found in all the text books, *is it true?* A quarter of an hour ago I took a rod of ebonite eighteen inches long (and the length is important); I rubbed its end on my coat, held it towards a small piece of light paper very thoroughly dried, and instantly stood the rod upon a holder a good distance from other bodies; that paper is still adhering to the rod upon its lower face, held up by attraction. I now brush it off on the table, excite my rod again, and hold it quietly just over the paper. This springs to the rod, flutters about between it and the table several times; then it stands on edge, and follows small motions of the rod; then appears to prefer to cling edgeways to the rod rather than the table, and at last lies down and clings to the rod.

I now make one of the prettiest repulsion experiments I know of. Instead of paper, I lay on the table a small piece—about ¼ of an inch square—of light gold leaf. I attract it with the excited rod, and then shake it off into the air. This requires careful management; the attraction must be from a distance, and the leaf will not abandon the rod very readily, or till the excitement has lowered; but, once in the air, the leaf may be guided at pleasure with the rod. It will not allow an approach. In this manner I drive the leaf over a gas-flame, so that the heated air rushes it up against the ceiling, whence it falls discharged. It can be caught again on the rod, which now attracts it, and the process repeated without freshly exciting the ebonite.

This is not repulsion, however, for the leaf will not readily leave the rod. It is a clear case of suspension and motion in a "field of force." The excited electric forms one electrode, and sets up a circuit through the body of the operator to the floor and the walls and ceilings, over which there is spread, in small density, the + charge corresponding to the dense — charge developed on the ebonite; from the ebonite lines of force or electric tension radiate to the walls. But while the leaf was on the rod it formed part of the — electrode, and remains, when separated, a distinct centre of a second field of force. Now, wherever the rod is placed these two fields interfere between the leaf and one surface; if it is placed below, the attraction from the floor is neutralised; the lines of force in that direction close on the rod, then the tension in the lines of force from the ceiling acts as an attractive force upwards, and the leaf rises. This occurs because the effect of its rising is to shorten the field of force centering on the leaf; the leaf, though rising against gravitation, is really running down hill electrically.

The same principles govern the motion of the two balls suspended side by side, or the gold leaves of the eletroscope. The diagram will explain this:



+ + are the two charged balls, and — — are the surrounding surfaces, to which proceed lines of force, developing attractions in the direction of the arrows. It is evident that the space enclosed between + and + and outwards towards *a* and *b* is a neutral field in which the opposing forces are indicated by the opposite arrows. There is, therefore, no attraction in this direc-

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tion to counterbalance that acting in the direction of the nearest —. It will be seen, therefore, that one + fulfils the functions of the excited rod in the floating leaf experiment, while the other + represents the leaf itself.

The idea of a repellent force naturally occurred to the early experimenters, who imagined that electricity was a something which could be isolated and placed upon a *single* surface; it is entirely out of place in any system which recognises the dual nature of electricity, and that it is just as impossible to have an isolated + or — charge of electricity as it is to have an isolated north or south pole of magnetism.

SCREW GAUGES.*

1. This committee was formed by the General Committee of the British Association assembled at York in August and September, 1881, for the purpose of determining a gauge for the manufacture of the various small screws used in Telegraphic and Electrical Apparatus, in Clockwork, and for other analogous purposes.

2. At that meeting a paper was read by Mr. Preece pointing out the desirability of establishing such a gauge. Although the Whitworth gauge is almost invariably adopted for the bolts and screws used in mill-work and engineering in England, no general system has been hitherto applied to the smaller screws used either in clockwork, philosophical instrument work, or in the numerous practical applications of electricity that are now rapidly becoming so important. In fact, at the present time gauges and screw plates almost equal in number the makers engaged in the trade. One instance was brought to the attention of the committee by a manufacturer who had to execute an order for railway signal apparatus in accordance with three sample instruments containing among them twenty-one screws of different threads, not one of which happened to be in use in his shop. There is now no recognised form of thread, no specified number of threads per inch—in fact, no generally accepted gauge based on practice and experience. Great inconvenience is felt in providing for repairs, which are, in consequence, more costly and less efficient.

The employment of some coherent and uniform system is manifestly required. It not only would render repairs easier, speedier, and cheaper, but it would introduce interchangeability of parts, and further the extension of piece-work; and it would reduce the equipment of workshops with special and costly tools.

3. The subject of uniformity in screws has been very warmly taken up by the Société des Arts de Genève, which appointed a committee in December, 1876, who, after assiduous labours, issued a report in 1878. The system proposed by them has been very fully described by Professor Thury in two pamphlets published in Geneva.† The committee collected numerous screws of all sizes from many factories, measured them carefully, tabulated their several dimensions, and plotted the results by the ordinary method of linear co-ordinates. They determined the mathematical equations to curves that most closely corresponded with the ratios of diameter to pitch thus found to have been employed in practice, and adopted the one which most nearly represented the mean average proportions of the screws in use at various shops and in different countries.

The Swiss Committee took 1 millimetre pitch as the basis of their system. It was agreed that such a pitch was best adopted to a screw having a diameter of 6 millimetres. The form of thread adopted was triangular, the angle made by producing the two sides being approximately 47½deg.; the depth being $\frac{3}{5}$ of the pitch, the top being rounded off by a radius $\frac{1}{6}$ and the bottom by a radius $\frac{1}{5}$ of the pitch.

The committee has had an opportunity of examining screw plates and numerous packets of the corresponding screws manufactured on the system.

The following table gives the pitches and diameters in millimetres and "mils ‡" to two significant figures, and the number of threads per inch of all the screws comprised in the small screw series, which happens to cover the exact ground to which the attention of the committee has been specially directed, namely, diameters below the ¼in.

Table of Swiss Screws.

No.	Pitch.		Diameter.		Threads per inch.
	Mm.	Mil.	Mm.	Mil.	
25	0·072	2·8	0·25	10	357
24	0·080	3·1	0·29	11	323
23	0·089	3·5	0·33	13	286
22	0·098	3·9	0·37	15	256
21	0·11	4·3	0·42	17	233
20	0·12	4·8	0·48	19	208
19	0·14	5·3	0·54	21	189
18	0·15	5·9	0·62	24	170
17	0·17	6·6	0·70	28	152
16	0·19	7·3	0·79	31	137
15	0·21	8·1	0·90	35	124
14	0·23	9·0	1·00	40	111
13	0·25	10·0	1·2	46	100
12	0·28	11·	1·3	52	91
11	0·31	12·	1·5	59	83
10	0·35	14·	1·7	67	71·4
9	0·39	15·	1·9	76	66·7
8	0·43	17·	2·2	86	58·8
7	0·48	19·	2·5	97	52·6
6	0·53	21·	2·8	111	47·6
5	0·59	23·	3·2	126	43·5
4	0·66	26·	3·6	142	38·5
3	0·73	29·	4·1	162	34·5
2	0·81	32·	4·7	183	31·2
1	0·90	35·	5·4	208	28·6
0	1·00	39·	6·0	236	25·6

It is to be observed that the numbers by which the screws are designated, given in the first column, are not arbitrary. Each pitch of the series is $\frac{9}{10}$ths of that which succeeds it in the table

Thus, the several pitches are:—

$$1 \text{ mm.}; \frac{9}{10} \text{ mm.}; \left(\frac{9}{10}\right)^2 \text{ mm.}; \left(\frac{9}{10}\right)^3 \text{ mm.}; \ldots \left(\frac{9}{10}\right)^n \text{ mm.}$$

This series may be expressed in the form:—

$$0{\cdot}9^0; 0{\cdot}9^1; 0{\cdot}9^2; 0{\cdot}9^3; \ldots 0{\cdot}9^n; \ldots \quad (1),$$

whence it is at once evident that the designating number of a screw is the index of the power to which 0·9 must be raised in order to ascertain its exact pitch in millimetres.

The method by which the relation between pitch and diameter is arrived at will be gathered from the following explanation:—

Let D represent the diameter and P the pitch. Then, generally,

$$D = f(P).$$

Evidently there can be no constant term, for when D = O, P must also = O. Moreover, D practically cannot be a simple multple of P, for experience has shown that small screws must have a less number of threads per diameter than large screws.

Hence the formula will be of the form

$$D = m P^k \quad \ldots \ldots \quad (2),$$

where m and k are constants to be determined.

Since 1^k is 1 whatever be the value of k, it follows that the coefficient m represents the value of D when P is 1. The Swiss Committee agreed that the unit pitch (1 millimetre) should be adopted for the screw having a diameter of 6 millimetres; in other words they make $m = 6$.

The value of k must be ascertained by trial.

$k = 1$ would give a constant ratio, which we know is inadmissable.

$k = 2$ will be found on trial to give a far too rapid decrease in the ratio of diameter to pitch.

The several simple fractions between these limiting values were tried in succession, and the results obtained when using $\frac{6}{5}$ were found to give results that best accord with practice and experience.

Substituting the values thus arrived at in (2), the formula becomes

$$D = 6 P^{\frac{6}{5}} \quad \ldots \ldots \quad (3).$$

The Swiss system is thus very complete, but there are reasons which prevent this Committee from recommending its adoption in its entiety.

4. No one has done more to establish gauges of all kinds in England than Sir Joseph Whitworth. His classical paper on "An Uniform System of Screw Threads" was communicated as

* Report of the British Association Committee, consisting of Sir Joseph Whitworth, Dr. Siemens, Sir F. J. Bramwell, Mr. A. Stroh, Mr. Beck, Mr. W. H. Preece, Mr. E. Crompton, Mr. E. Rigg, Mr. A. Le Neve Foster, Mr. Latimer Clark, Mr. Buckney, and Mr. H. Trueman Wood (secretary), appointed for the purpose of determining a gauge for the manufacture of the various small screws used in telegraphic and electrical apparatus, in clockwork, and for other analogous purposes.

† *Systématique des vis Horlogères*, Geneva, 1878. *Notice sur le Système des vis de la Filière Suisse*, Geneva, 1880.

‡ The "mil" is the thousandth part of the British inch.

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far back as 1841 to the Institution of Civil Engineers. He had made an extensive collection of screw-bolts from the principal workshops throughout England, and the average thread was carefully measured for different diameters. The ¼, ½, 1, and 1½ inch were selected and taken as the fixed points of a scale by which the intermediate sizes were regulated. The result is an admirable thread for the large iron bolts and screws used in fitting up steam engines and other machinery. The angle made by the sides of this thread is 55deg. One-sixth of the depth of the thread is rounded off from the top, and one-sixth from the bottom. The actual depth is rather more than three-fifths, and less than two-thirds of the pitch.

The slow adoption of such an admirable system was perhaps due, in great measure, to the fact that it was put forward by an individual and not by an association. A single individual, however exalted his reputation, cannot secure that immediate and universal attention which is obtained by such an organisation as the British Association. The system of units of electrical measurements sanctioned by the association obtained instant recognition, and has now, thanks to the Congress of Electricians held in Paris in October, 1881, become universally accepted. It is hoped that the same result will follow the recommendations of this committee.

5. The question of the introduction of the metrical system occupied the serious consideration of the Committee, but, considering the fact that it is not generally adopted in engineering or manufacture in England, and that it is as yet little understood by our workmen, it was thought better to suggest no change in this direction. The Committee is not insensible to the simplicity of the metrical system and to its possible universality, nor to the fact of its gradual introduction in scientific circles, but while the manufacturing interests are still wedded to the British inch and its multiples and sub-multiples, and while the British legal standard of length is still the yard, the Committee has felt it impossible to suggest a change which has little chance of adoption, and which might jeopardise the introduction of that with which they are more concerned—viz., a uniform screw-thread.

Hence it was determined that the unit of length taken should be the "mil," and that the decimal system should be adopted for expressing dimensions.

6. The use of a screw is to draw together and to unite certain parts of apparatus in firm and intimate contact. To attain these ends a screw must facilitate the application of mechanical power to draw the parts together, and it must possess strength to hold them so; it must not interfere with the easy separation of these united parts when necessary; it must possess durability—that is, it must be capable of repeated use without undue friction and without wear, otherwise it will speedily become loose and dangerous when frequently removed and restored. There has to be considered the pitch of the screw, its relation to the diameter of the bolt on which it is cut, the depth of the cut, and the form of the thread. The pitch primarily determines the power of the screw, for it determines, for each diameter, the angle of the inclined plane; the depth determines the section of core left to resist shear or rupture; while the form of the thread determines the durability and efficiency, and determines also the surface of thread to bear endway strain.

7. The Committee have devoted very considerable attention to the pitch, form, and depth of screws, and they have compared together a large number of different kinds, some of which are in actual use, while others have only been suggested. They have, moreover, decided on recommending the adoption of the Whitworth form of thread, not only because it is so well known, but because experience has proved it excellent and unsurpassed when employed for engineers' bolts. The Committee, however, are not unanimous on all questions involved by this proposal, and as there are several points that require to be thoroughly sifted and tested, they ask to be reconstituted and to be allowed a small grant to put their proposal to the test of practice, and to have a few gauges constructed for distribution or examination.

DETECTION OF METALLIC MASSES IN THE HUMAN BODY.*

BY ALEXANDER GRAHAM BELL.

(CONTINUED FROM PAGE 140.)

Continuing the experiment, the coil B was moved a determined distance beyond the plane of A, and the balancing coils again adjusted to silence. The brass ring C was once more caused to disturb the balance, and the new hearing distance was noted. The following are the tabulated results of a series of experiments made on the 19th July, 1881. The battery employed consisted of six bichromate cells connected in series:—

Diameter of Primary Ring.	Distance between—			Diameter of Primary Ring.	Distance between—		
	A B.	B C.	A C.		A B.	B C.	A C.
mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
	0	17	17		0	27	27
	5	14	19		5	20	25
30	10	13	23	159	10	18	28
	20	9	29		20	17	37
	30	7	37		30	14	44
	50	0	50		50	14	64
	0	17	17		0	12	12
	5	19	24		5	18	23
50	10	26	36	206	10	25	35
	20	17	37		20	19	39
	30	14	44		30	22	52
	50	5	55		50	18	68
	0	21	21		0	20	20
	5	23	28		5	18	23
81	10	23	33	253	10	20	30
	20	18	38		20	19	39
	30	14	44		30	23	53
	50	12	62		50	20	70
	0	22	22				
	5	25	30				
113	10	27	37				
	20	26	46				
	30	26	56				
	50	17	67				

These figures show that *the distance from the primary coil* A (Fig. 8) *at which the influence of the brass ring* C *became perceptible increased with the diameter of the primary ring, and that the secondary coil* B *required to be projected considerably beyond the plane of the primary in order to obtain the maximum effect.*

The conclusion seemed a natural one that the degree of projection A B of the secondary coil should proportionally increase with the diameter of the primary ring, but the tabulated figures did not fully justify the inference.

The experiments had necessarily occupied a considerable time, and I thought that the difference between the results that should have been observed, according to the above hypothesis, and those that were actually obtained, might have been due to the gradual exhaustion of the bichromate battery employed and to its polarisation, although every care had been taken to preserve its power by removing the carbon and zinc plates from the solution, excepting when an observation was made. To test whether the battery exerted any material influence upon the hearing distance, a further series of experiments was made with the same battery.

It will be seen by reference to the tabulated statement shown above that the maximum hearing distance B C had been obtained with a primary ring 11·3cm. in diameter when the distance A B between the primary and secondary coils was one centimetre. This arrangement of the apparatus was, therefore, adopted throughout the following experiments:—

	Hearing distance.
1. Apparatus tried with 1 cell (bichromate battery) (B C, Fig. 8)	= 9 mm.
2. Six cells in series (B C, Fig. 8)	= 16 mm.
3. Six cells in multiple arc (B C, Fig. 8)	= 9 mm.
4. Six cells in two series of 3 each (B C, Fig. 8)	= 15 mm.
5. Same experiment repeated (B C, Fig. 8)	= 13·5mm.
6. Same experiment repeated by Mr. Tainter (B C, Fig. 8)	= 12·5mm.

These experiments proved that the battery power *did* exert an influence upon hearing distance, and also that the battery in use was gradually deteriorating.

I concluded, therefore, that if the battery power had remained constant, the hearing distance might not only have been proportional to the diameter

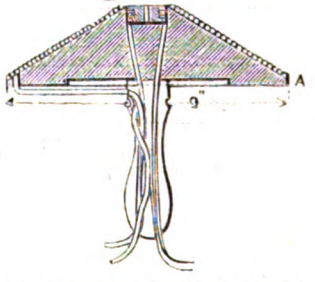

FIG. 9.—(Secondary Coil, 1 inch.)

of the primary ring, but, in order to attain the maximum effect, the projection of the secondary coil beyond the plane of the primary might also have been found to increase in like proportion.

This led me to try the effect of a conical primary coil, A, with the secondary, B, at its apex, as shown in Fig. 9, but the hearing distance for a bullet was only 3·5 cm.

Singularly enough, Mr. J. H. C. Watts, in Baltimore, had independently arrived at a very similar form of coil, and with the instrument shown in

* A Paper read before the American Association for the Advancement of Science at the Montreal Meeting, August, 1882.

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Fig. 10 he had obtained at one time a hearing distance of 7·5 cm. (or 3in.*), but from some cause not ascertained he was unable subsequently to reproduce the effect.

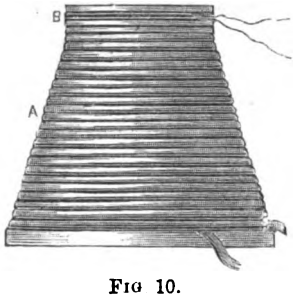

FIG 10.

The final form of apparatus adopted as the result of the above experiments is shown in Fig. 11. With this arrangement and a battery of six bichromate elements freshly set up, we were always sure of a hearing dis-

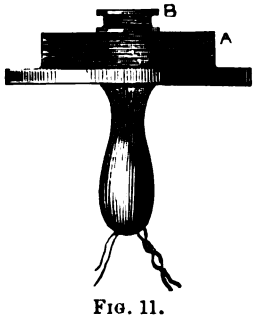

FIG. 11.

tance of at least 5 cm., although after the battery had been in use for some time the hearing distance hardly exceeded 4 cm.

The following are the dimensions of the coils A B (Fig. 11) and their resistance :—

COIL A.....	External diameter	7 cm.
	Internal diameter	4·5 cm.
	Depth	2·4 cm.
Wire used, No. 23 (cotton covered). Resistance, 2 ohms.		
COIL B.....	External diameter	2·3 cm.
	Internal diameter	8 mm.
	Depth	8 mm.
Wire used, No. 36 (silk covered). Resistance, 75 ohms.		

The face of the coil B projected beyond the face of coil A 4 mm.

The balancing coils were made as nearly as possible the duplicates of A and B. The resistance of the coil of the telephone employed was 75 ohms.

Influence of Battery Power.

The following experiments were made with this apparatus (Fig. 11) on July 20, 1881, to test the influence of battery arrangements upon the hearing distance of a leaden bullet.

I. *Series of experiments with a bichromate battery which had previously been in use for a few minutes.*

	Hearing distance of leaden bullet as observed by	
	A. G. Bell.	S. Tainter.
	cm.	cm.
1 cell.....	2·4	2·6
2 cells in series	3·3	3·5
3 cells in series	3·7	4·1
4 cells in series	3·7	4·0
5 cells in series	4·0	4·1
6 cells in series	4·3	4·4
6 cells in multiple are	2·6	2·9
6 cells in two series of 3 each	3·8	3·7
6 cells in three series of 2 each ...	4·3	4·0

II. *Series of experiments with a Leclanché battery of twenty cells which had been set up for about one month. It had been kept normally upon open circuit, and had only been occasionally used.*

	Hearing distance.
20 cells in series.....	3·3 cm.
20 cells in 10 series of 2 each	3·6 cm.
20 cells in 5 series of 4 each	4·1 cm.
20 cells in 2 series of 10 each	3·0 cm.

Although the battery appeared to be in good condition, a close inspection showed that the connections were dirty, and that one of the zinc wires was half broken through.

* See Appendix, note 11.

The defective cell was now removed from the circuit, and the connections of all the other cells cleaned and tightened.

III. *The following experiments were then made with the Leclanché cells united in series:*

No. of cells.	Hearing distance.	No. of cells.	Hearing distance.
	cm.		cm.
1	2·7	11	3·8*
2	2·8	12	4·2
3	3·0	13	4·2
4	3·3	14	4·2
5	3·3	15	4·3
6	3·5	16	4·2
7	3·6	17	4·2
8	3·8	18	4·2
9	4·0	19	4·2
10	3·8*		

These results are graphically represented in Fig. 12.

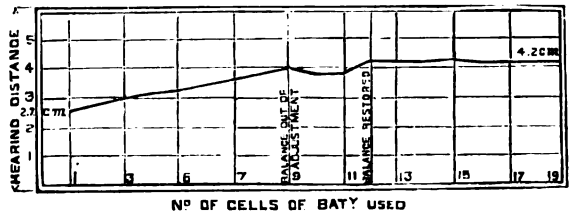

FIG. 12.

It will be observed that the hearing distance was carried nearly one-third as far again as at first, simply by increasing the number of cells employed without any other change in the arrangement. It will also be noticed that the apparatus requires to be adjusted to complete silence in order to obtain the maximum effect.

As a general result of all our experiments with voltaic batteries, we find that *it is advisable to use a battery possessing great electromotive force and slight internal resistance, and to connect the cells in series.*

Experiments upon Living Subjects.

On the 22nd of July an experiment was made at the request of Dr. Bliss upon the person of Lieutenant Simpson, who had carried a bullet in his body for many years.

When the exploring instrument (Fig. 11) was passed over the lieutenant's back a sonorous spot was found, but the indications were too feeble to be implicitly relied upon. Imagination very easily conjures up a feeble sound like that observed, but a number of experiments by different observers seemed to indicate that in this case there was an external cause for the sound—probably the presence of a very deeply-seated bullet. The results of this experiment were communicated to Dr. Bliss in a letter dated July 23rd, 1881.†

On the 25th of July Professor Rowland visited me at Washington, and suggested the use of a condenser in the primary circuit. I had previously discussed this idea with Mr. Tainter, but, not having a condenser at hand, we had been unable to make any experiment. After our conversation with Professor Rowland, however, we were so impressed by the importance of the point that we obtained a condenser next morning, and found it to produce not only a different quality of sound when the bullet approached the coils, but also to increase the hearing distance of the instrument shown in Fig. 11 at least one centimetre.

On the evening of the same day (July 26th) our apparatus was carried to the executive mansion, and an experiment made upon the person of the President.‡

From some cause then unknown a balance could not be obtained, and the results were therefore uncertain and indefinite. It was discovered afterwards that a mistake had been made in the mode of connecting the con-

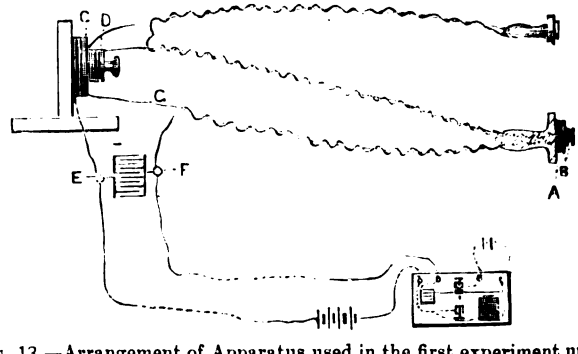

FIG. 13.—Arrangement of Apparatus used in the first experiment upon the late President Garfield, July 26, 1881.

denser. The latter should have been connected at E F (Fig. 13), whereas it was placed at E G, thus influencing only one, instead of both, of the primary coils.

With the condenser properly arranged experiments were tried on July 29

* Balance not quite perfect. † See Appendix, note 12. ‡ See Appendix, note 13.

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and 30 on three soldiers from the Soldiers' Home who had been wounded during the civil war, namely, John Teahan, Asa Head, and John M'Gill.

In the case of John Teahan no results were obtained. In the case of Asa Head, who had a buckshot in the cheek, loud and well-marked sounds were heard in the telephone; and in the case of John M'Gill, who was supposed to carry a bullet in his back, no results were obtained.

Further efforts were then prosecuted for the improvement of the apparatus.

Further Experiments to Improve Apparatus.

Our attention had hitherto been directed chiefly to modifications of the exploring instrument. We now investigated the effect, upon the hearing distance, of the coils used to obtain a balance.

The following experiments, made July 29, 1881, bear upon the point: –

Exp. 1. (See Fig. 14.) Resistance of primary A of exploring instrument, 2 ohms; resistance of primary C of balancing coils, also 2 ohms; resistance of exploring secondary B, 140 ohms; and of balancing secondary D, 120 ohms.

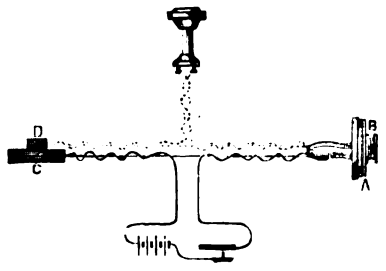

Fig. 14.

Result: Hearing distance of bullet from explorer A B, 3·5 cm. Hearing distance from balancing coils C D, also 3·5 cm.

Exp. 2. (See Fig 15.) Same exploring coils as in Exp. 1, but balancing coils consisted of a flat primary, E—resistance, 5·30 ohms; and flat secondary, F—resistance, 83 ohms. The adjustment was made by sliding the secondary coil upon the primary until a position of silence was obtained.

Result: Hearing distance from explorer A B, 1·5 cm. Hearing distance from E F, 3 cm.

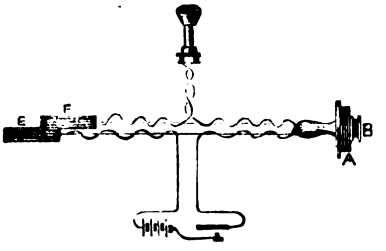

Fig. 15.

As a general result of our experiments we found that *every increase in the resistance of the balancing coils (especially the primary) reduced the hearing distance of the exploring instrument*, and it became therefore desirable to do away with this source of resistance as much as possible.

Return to Original Form of Apparatus.

This led us back to the original form of apparatus that had first occurred to me (see Fig. 1), in which a single pair of coils was employed. A few other experiments, made July 29, 1881, will show the importance of the point attained.

Exp. 3. The two flat coils E F used in Experiment 2 were arranged as in Fig. 16, so as to form a balance by themselves.

Result: Hearing distance, 7 cm.

In all these experiments the battery used consisted of four cells (Leclanché).

Fig. 16.

Exp. 4. The same coils used in Exp. 3 were tried again, as shown in Fig. 16, but with a battery of eight cells (Leclanché).

Result: Hearing distance, 8·7 cm., or nearly 3½in.—a result quite unprecedented in our experiments.

The following are the dimensions of the coils E F:—

Coil E.....	External diameter	10 cm.
	Internal diameter	2·5 cm.
	Depth.....	1 cm.
	Wire used, No. 23 (silk covered).	
Coil F.....	External diameter	10 cm.
	Internal diameter	2·5 cm.
	Depth.....	1 cm.
	Wire used, No. 28 (silk covered).	

Exp. 5. The same coils, E F, used in Exps. 2, 3, and 4, were tried once more with a battery of six large bichromate elements, and with a condenser, G, in the primary circuit as shown in Fig. 17.

Result: Hearing distance 13cm., or more than 5in.

This great increase in hearing distance seemed to be chiefly due to the condenser, for upon disconnecting it the hearing distance was little more than 9cm., but further experiments proved that other causes also contributed to the result.

Exp. 6. When the condenser was in circuit and the leaden bullet close to the coils (arranged as in Fig. 17) the sound produced by the telephone was a musical note whose pitch was the same as that normally produced by the vibration of the reed of the interrupter. Mingled with this tone could be distinguished a number of feebler tones of very much higher pitch. Upon withdrawing the bullet gradually from the coils the fundamental sound became fainter, and one of the high upper-partial tones gradually acquired

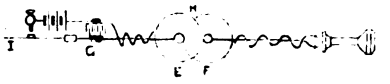

Fig. 17.

prominence; and at a distance of about 8 or 9cm. the fundamental could no longer be distinguished, but the high tone persisted, and was clearly audible up to a distance of 13cm. The effect was very striking, and when the bullet was moved to and fro parallel to the plane of the coils E F at a distance of about 10cm., the telephone emitted a shrill whistling sound each time the sensitive area (H) was passed.

It was noticed that other metals, such as iron, brass, and copper, did not seem to reinforce this high tone to any great extent, but brought out the fundamental at every distance where an effect was produced.

Exp. 7. The condenser G (Fig. 17) was removed from the circuit and the leaden bullet held about 4 or 5 cm. from the coils E F. The fundamental tone was heard, and the characteristic upper-partial could also be distinguished, but it was only faintly audible. Upon now suddenly replacing the condenser the high upper-partial tone was instantly reinforced as if by a resonator.

Exp. 8. The rheotome employed to interrupt the primary circuit (which had been placed in a distant room) was found to be vibrating badly. The reed I of the instrument (see also Fig. 5) was rattling against its contact pieces, thus producing an impure sound, and I could distinguish amongst the upper-partials the tone that had been reinforced by the condenser. Upon screwing up the contact pieces so as to improve the vibration I could no longer distinguish the particular upper-partial referred to, and upon returning to the room in which the coils E F (Fig. 17) were placed I could no longer detect the effects noted above in Exps. 6 and 7, and the hearing distance did not exceed 9 cm.

The peculiar effects obtained with the arrangement shown in Fig. 17 thus seemed to depend (1) *upon a particular kind of vibration of the reed of the interrupter, producing a certain high upper-partial or overtone,* (2) *upon the use of a condenser acting as a sort of electrical resonator for this tone, and* (3) *upon the use of the metal lead.*

(TO BE CONTINUED.)

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Dec. 27.		Business Done Week Ending Dec. 27. Highest.		Lowest.	
Anglo-American	48½,	49½	48¾		48¼	
Do. Preferred	79½,	80½	80		78¾	
Do. Deferred	17½,	18½	18¾		18¼	
Brazil Submarine	11½,	12	12		11¾	
Cuba	9½,	10½	—		—	
Do. Preference	17,	18	17½		17½	
Direct Spanish	6½,	7	6¾		6¾	
Do. Preference	16,	17	16½		16½	
Direct United States Cable	11½,	11¾	11¾		11¼	
Eastern Telegraph	11,	11½	11½		11	
Do. 6 per Cent. Preference	13½,	13¾	13½		13 5-16	
Do. 5 per Cent. Debentures, 1899	104,	107	—		—	
Eastern Extension	11½,	12½	12½		12	
German Union	10½,	10¾	10½		10½	
Globe Telegraph and Trust Company.	6¼,	6¾	6¼		6 5-16	
Do. Preference	12½,	13	12¾		12¼	
Great Northern	12¼,	12½	12½		12½	
Indo-European	31,	32	—		—	
Mediterranean Extension	1½,	2	—		—	
Do. Preference	6,	8	—		—	
Reuter's	12½,	12¾	—		—	
Submarine	250,	255	—		—	
West India and Panama	1½,	1¾	1¾		1¾	
Do. 1st Preference	7,	7½	—		—	
Western Brazilian	7½,	8¼	8		7¾	
West. Union 7 per Cent. 1st Mortgage	122,	126	—		—	
Do. 6 per Cent. Sterling Bonds	102,	105	—		—	

TELEPHONES.

Consol. Telephone and Maintenance	¼,	½	½		¼
Oriental	½,	¾	13-16		¾
United Telephone	11,	11½	11½		10 13-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	6½,	6¾	6¾		6 1-16
Do. (fully paid)	11,	14	13¾		12¾
Hammond Light	3¼,	3¾	3¾		3¾
Eastern Electric (£4 paid)	1¼,	1¾	1¾		1¼
Pilsen, Joel, and General Electric	1,	1½	1½		1½
Swan	1¾,	2	1 15-16		1 15-16
Maxim-Weston	¾,	¼	7-16		7-16

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THE FAURE ELECTRIC ACCUMULATOR COMPANY (Limited), 71, Queen Street, Queen Victoria Street, London, E.C.---NOTICE is hereby given that the SUBSCRIPTION LIST for 25,000 Preference Shares in the French Electrical Power Storage Company, Limited, will CLOSE on SATURDAY, the 30th day of December, 1882, for LONDON and the COUNTRY.---Subscriptions received at the London and County Banking Company, Limited, 21, Lombard Street, London, E.C., and Branches.

By order, HERBERT CANNING, Secretary.

THE FAURE ELECTRIC ACCUMULATOR CO., LIMITED,

OFFERS FOR PUBLIC SUBSCRIPTION

25,000 Preference Shares of the French Electrical Power Storage Company, Limited

These Preference Shares, numbered 1 to 25,000, inclusive, are redeemable in 30 years, from the 1st of January, 1884, at £20 or 500 francs, per share, by drawings as set forth in the tabular form hereunto annexed.

Pending their redemption, these shares will be entitled to a half-yearly payment of interest of six shillings, or seven francs fifty centimes, per share, on and after the 15th of July, 1883, such interest to be payable at the offices of the Faure Electric Accumulator Company (Limited), in London and Paris.

The payment of the interest on the said 25,000 shares is absolutely guaranteed by the Faure Electric Accumulator Company (Limited).

These shares will further participate, in their due proportion, in the 25 per cent. of the profits of the French Electrical Power Storage Company (Limited) reserved to the preference shares of that company, as set forth in its Articles of Association.

These shares are offered for public subscription at the price of £12 sterling per share, payable as follows:—£1 per share on Application; £2 per share on Allotment; £3 per share on February 15th, 1883: £3 per share on April 15th, 1883; £3 per share on July 15th, 1883.

Any subscriber paying up his shares in full on or before the 15th January, 1883, will be entitled to a discount of six shillings per share, and will further be entitled to a share certificate to bearer, free of charge.

No. of Shares to be drawn in—

1884	525	1892	666	1900	844	1908	1,069
1885	541	1893	686	1901	869	1909	1,102
1886	557	1894	706	1902	895	1910	1,135
1887	574	1895	728	1903	922	1911	1,169
1888	591	1896	750	1904	950	1912	1,204
1889	609	1897	772	1905	978	1913	1,228
1890	623	1898	795	1906	1,008		
1891	647	1899	819	1907	1,038		25,000

The utility and the practical and economic value of accumulators is to-day universally acknowledged, and it is sufficient on this head to cite the speeches and written testimony of Sir William Thomson, Professors Ayrton and Perry, Sylvanus Thompson, and Messrs. Cromwell Varley, Clarke Forde, and Co., Niaudet, Hospitalier, Franck Géraldy, and numerous other eminent electricians.

It is only by means of accumulators that can be solved the problem of the production on a large scale of electric energy, either at the pit's mouth or by the utilisation of waterfalls and other natural forces, and its transport by means of cables, for the purpose of distribution and consumption in industrial centres hundreds of miles distant.

The accumulators patented by Messrs. Faure, Sellon, and Volckmar are certainly the only ones in existence that are practical and economical; indeed, in consequence of the great progress that has been made in their manufacture, it may be calculated that the cost price of a ton of accumulators does not exceed £30 sterling, nor their maintenance more than £6 sterling, for a useful yield of 2,000 ampere-hours, during six hours, which is equal to effective work of more than 30 horse-power hours.

The French Electrical Power Storage Company (Limited) possesses the exclusive right to make, sell, and exploiter the Faure, Sellon, and Volckmar Accumulators in France and the French colonies, and the profits to be derived from the monopoly of a like invention for a country like France are incalculable. Some idea of these profits may be arrived at from the fact that the lighting alone of the City of Paris costs annually more than £3,000,000 sterling, and the motive power in the same city exceeds 25,000 horse-power.

The French Electrical Power Storage Company (Limited) has already ceded its rights for the Departments of the Seine, Seine and Oise, and Seine and Marne, to the French Metropolitan General Electric Company (Limited), which has been formed with a capital of £1,200,000, but the French Electrical Power Storage Company (Limited) retains 50 per cent. of the profits of the new company, in addition to the exclusive right of supplying accumulators and other apparatus at remunerative prices.

Negotiations are in progress for the formation of similar companies in other departments of France on like conditions.

The first series of 25,000 Preference Shares in the French Electrical Power Storage Company (Limited) is now offered to the public by the Faure Electric Accumulator Company (Limited), at the price of £12 per share, and at this price these Preference Shares will yield a fixed revenue of 5 per cent., payable half yearly; and, as they are further redeemable by drawings in 30 years at the price of £20 sterling—or 500f.—the bonus of this drawing, which amounts to £8 per share, is equal to a further annual dividend of more than 3 per cent., without taking into consideration their proportional part of the 25 per cent. of the surplus profits to which these Preference Shares are entitled.

The Faure Electric Accumulator Company (Limited) guarantees the fixed payment of interest on these shares, and, consequently, the holders thereof will, as to the interest, be virtually debenture holders of the said Faure Company, as well as shareholders in the French Electrical Power Storage Company (Limited).

Subscribers to this issue will be entitled to subscribe on similar terms to all other issues which may be offered to the public.

Subscriptions will be received in London by

THE LONDON AND COUNTY BANK, Limited, 21, Lombard Street, E.C.

FORM of APPLICATION for PREFERENCE SHARES of the FRENCH ELECTRICAL POWER STORAGE CO. (Lim.).

To the Directors of the Faure Electric Accumulator Co. (Lim.), 71, Queen-street, Queen Victoria-street, London, E.C.

GENTLEMEN: Having paid to the London and County Bank (Limited) the sum of pounds, being a deposit of £1 per share on Preference Shares in the French Electrical Power Storage Company (Limited), I hereby request that you will allot me that number, upon the terms of the annexed Prospectus, and I agree to accept the same, or any less number you may allot to me, and to pay the deposit upon allotment of £2 per share.

Signature in full .....
Address in full .....
Profession or Occupation (if any) .....
Date 188

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SLIP

MARANHAM AND PARA.—The cable between Fortaleza and Maranham is now repaired.

EASTERN ELECTRIC LIGHT AND POWER COMPANY.—Mr. Walter Jackson has been appointed secretary of this company.

ELECTRIC LIGHTING IN BRISBANE.—A company is being formed in Brisbane, Queensland colony, to introduce and work the Brush system.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended December 29, 1882, amounted to £3,095.

THE MAGAZINES.—The *Zoophilist* for January contains an article by Mr. St. George Lane-Fox on the humane slaughter of aged horses by electricity.

MR. FAWCETT.—The Postmaster-General is, we are glad to be able to announce, so far convalescent that all apprehensions as to his complete restoration are now entirely removed.

THE GREAT NORTHERN TELEGRAPH COMPANY.—This company give notice that 50 debentures, issued by the company, and variously numbered, have been drawn for payment.

THE TELEGRAPH IN BRITISH GUIANA.—Since the introduction of the sixpenny rate, says the *Colonies and India*, the number of telegraphic messages sent within this colony has increased nearly fourfold.

NEW TELEGRAPH OFFICE AT MELBOURNE.—It is stated that the Victorian Government have decided to erect a new central telegraph office in Melbourne, next to the General Post Office. It is to cost about £17,000.

POSTS AND TELEGRAPHS IN VICTORIA.—The revenue derived by the colony of Victoria during 1882 from the postal and telegraphic services amounted to £312,000, or an increase of £27,000 over the revenue from the same sources in 1881.

BUSINESS NOTICE.—The business of E. Fox and Co., of Millwall, wire manufacturers, has been turned into a limited liability company, under the title of Edwin Fox and Co. (Limited), and the City offices are at 5, Great Winchester-street, E.C.

THE FERRANTI DYNAMO MACHINE.—We are informed that the Australasian Electric Light and Power Company have taken the sole agency for the Ferranti dynamo-electric machine in the Australias, and the first machine will be sent out shortly.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending December 29th, 1882, were £2,036, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE MARSEILLES-BARCELONA CABLE REPAIRED.—The Direct Spanish Telegraph Company inform us that their cable between Marseilles and Barcelona is restored, and that telegrams for Barcelona and other places in Spain can again be sent by that route.

DIRECT COMMUNICATION BETWEEN LONDON AND SPAIN.—The Direct Spanish Telegraph Company having acquired a special wire between London and Falmouth, the direct Spanish cable to Bilbao is now worked direct from the company's station, No. 1, Leadenhall-street, E.C.

ELECTRIC LIGHTING COMPANIES' CAPITAL.—The *Journal of Gas Lighting* says that at the end of last year (1882) "the nominal capital of the various registered electric lighting companies amounted to £24,895,500; of which, however, not quite three millions sterling appear to have been actually paid up by the public."

MR. SWAN.—Mr. J. W. Swan, the inventor of the incandescent lamp so well known by his name, is about to take up his abode permanently near London, instead of Newcastle-on-Tyne, this migration being occasioned by the pressing claims which the Swan United Electric Light Company's business has upon Mr. Swan's time.

HONOURS FOR AN ELECTRICIAN.—Herr Bunsen, the celebrated inventor of the Bunsen battery, has been elected a Foreign Associate of the Academy of Sciences, Paris. There are but eight such associates, of whom Sir William Thomson is the only one besides Herr Bunsen whose name can be said to be connected with electrical science.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of December was 2,954, estimated to produce £2,800, against 2,672 messages, producing £2,741, in the corresponding month of last year. The traffic receipts for the month of September, estimated at £2,250, realised £2,283.

ELECTRIC LIGHTING FOR TRAINS.—A telegram, dated Vienna, December 31, which appeared in a daily contemporary, says:—"Experiments have recently been making for the application of the electric light to the trains of the Southern Railway of Austria, and in a few days the first electrically lighted train will be run from Vienna to Neustadt."

THE TELEPHONE IN PORTUGAL.—The Edison Gower-Bell Telephone Company of Europe have recently obtained a royal subscriber to their Lisbon exchange in the person of the King of Portugal. His Majesty, in addition to the line leading to his palace, is having his private apartments connected with the various ministries and the opera by the same company.

WEST INDIES AND BRITISH GUIANA.—The cable between Antiqua and Guadeloupe is repaired, and telegraphic communication restored with Guadeloupe, Dominica, Martinique, St. Lucia, St. Vincent, and Barbadoes. The cables between St. Croix and Trinidad, and between Trinidad and Demerara, however, are now interrupted, and as the cable between St. Vincent and Greneda is not yet repaired there is no telegraphic communication with Greneda, Trinidad, and British Guiana.

PERSONAL.—From an American contemporary, one of whose columns is marked with the blue pencil considered requisite to catch editorial eyes, we learn that Dr. H. R. Rogers, of Dunkirk, New York State, has been elected a corresponding member of the New York Academy of Sciences. Dr. Rogers is not unknown to our readers. We recently printed a lengthy article from his pen, entitled "The Primordial Force." We are glad to chronicle the honour conferred on Dr. Rogers.

THE EDISON SYSTEM IN THE "CITY TEMPLE."—During service on the last day of the old year, the whole of the Edison lamps by which the City Temple is lighted were extinguished, owing, we believe, to some breakdown in the machine room. Dr. Parker assured his congregation there was no danger, and fortunately no panic occurred. Nothing can provide against a breakdown of machinery but accumulators, and accidents of this kind emphasise their necessity. Dr. Parker is to be congratulated on his coolness and tact.

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THE PARIS EXHIBITION.—In the last issue of *La Nature* is a very good illustration of the medal struck in commemoration of the Great Electrical Exhibition of 1881, held in Paris. On the face of the medal is an allegorical figure representing Science, in the form of a goddess, lighting by means of lightning the torch with which she illumines the world. On the reverse side are engraven the names of M. Grévy, President of the French Republic; M. Cochery, Minister of Posts and Telegraphs; and M. Berger, the Commissary-General of the Exhibition.

PROFESSOR PALMIERI.—In its obituary for 1882, our excellent contemporary, the *Daily News*, perpetuates an error which was, we believe, first made public by a French paper. We ourselves must plead guilty to having been taken in by it at the outset, but on ascertaining our mistake, did our best to correct it. The error alluded to is the announcement of the death of Professor Palmieri, of Italy. The fact is that a male relation of the Professor has passed away during the year, but not the professor himself, who, we have have every reason to believe, is hard at work in his observatory on Mount Vesuvius, and in good health.

THE TELEPHONE IN AUSTRIA-HUNGARY.—On the 25th October, 1882, there were in Buda-Pesth 320 subscribers to the Local Telephone Exchange out of a population of 320,000. At Trieste, on the same date, there were 50 subscribers to the exchange there out of a population of 112,000. The exchanges at both these places belong to the Central Telephon Gesellschaft, of Vienna. This company has obtained Government concessions for the establishment of exchanges in Graz, Lemberg, Krakan, Brünn, and Temesvar, but these are not yet working. The price of the annual subscription is 180 florins in Pesth and 90 florins in Trieste. The length of the company's concession in Pesth is 20 years, and in Trieste 10 years.

ELECTRICAL ENGINEERING.—Professor W. Grylls Adams, F.R.S., will deliver a course of lectures on Voltaic and Dynamic Electricity and Magnetism, and their applications to Cable-testing, Electric Lighting, &c., at King's College, Strand, W.C., during the ensuing session. A course of practical work in electrical testing and measurement with especial reference to electrical engineering will also be carried on under his direction in the Wheatstone laboratory. The lectures will be given once a week, on Mondays, at 2 p.m., and the laboratory will be open daily (Saturdays excepted) from 1 to 4. The work will begin on Monday, January 15. For further particulars apply to Professor Adams, King's College, London.

THE EASTERN TELEGRAPH COMPANY.—This company have just issued a revised edition of their tariff book, which contains all the latest changes in tariffs, &c., up to December last. It is a model of what a book of its class should be, and that is the highest praise we can bestow upon its compilers. In addition to the usual information as to tariffs, the book contains no less than ten maps, splendidly engraved on steel, on which the various cables and chief landlines of the world are marked in colours. The Eastern Telegraph Company are to be congratulated on the enterprise which produces such a book as that now lying before us. We may mention that the maps have been engraved, and the book printed by Messrs. Waterlow and Sons, of London-wall, E.C.

ELECTRIC LIGHTING AT WILLIS'S ROOMS.—One of the most successful incandescent installations yet made is that in Willis's Rooms, which were lighted up for the first time on Tuesday night by the Metropolitan (Brush) Electric Light and Power Company. The work, owing to the confined space at disposal, and to other local circumstances, was one of exceptional difficulty. The lighting, however, elicited warm expressions of approval from the numerous company assembled. The work has been carried out to the satisfaction of Mr. Musgrave Heaphy, C.E., of the Phœnix Fire Insurance Company, who superintended the installation on Messrs. Willis's behalf. The existing chandeliers and brackets were utilised without any disfigurement of wall or ceiling.

ROUNDABOUT TELEGRAPHY.—At a recent meeting of the Falkirk town council Councillor Allan directed attention to the delays in telegraphing from Falkirk to Glasgow, and also to Grangemouth, on account of Falkirk not having any direct communication with these places. At present a message can be sent quicker by rail to Grangemouth than by telegraph, because a telegram is first sent to Edinburgh, then retransmitted to Glasgow, and ultimately sent direct from Glasgow to Grangemouth. In the same way all telegraphic messages to and from Glasgow have to be sent first to Edinburgh and retransmitted. It was unanimously resolved to memorialise the Postmaster-General, requesting that Falkirk should be placed in direct telegraphic communication with both Grangemouth and Glasgow.

THE ELECTRIC LIGHT AND TEXTILE MANUFACTURERS.—The Mayor and Corporation of Leicester and the leading manufacturers visited the hosiery manufactory of Messrs. Corah, Sons, and Cooper, Leicester, last week, to witness the first introduction of the electric light into a textile factory in the town. The many shades of yarns used in ladies' jerseys and other fancy fabrics make it difficult to manufacture and make up these goods by gas light, but on this occasion it was proved that colours undistinguishable by gas light were easily matched by the electric light. The Brush arc and Swan incandescent lamps are used. Leicester is not the first town by any means where this fact has been ascertained, and many textile manufacturers and dyers have adopted the electric light, including the well-known Messrs. Fuller, of Perth.

A COMBINATION.—The Gramme Electrical Company, of New York, controls the American patents belonging to the following companies:—The American Electric Company, of New Britain, Connecticut; the Brush Electric Company, of Cleveland, Ohio; the Edison Electric Light Company, of New York; the Fuller Electrical Company, of New York; the Jablochkoff Electric Lighting Company, of New York; the United States Electric Lighting Company, of New York, and the Weston Electric Light Company, of Newark, New Jersey; and has given notice that it will prosecute any one infringing any such patents. It appears from a list lying before us that the earliest of these patents was taken out by Farmer on December 12, 1865, and relates to a thermo-electric battery. The total number of patents controlled by the Gramme Company, according to this list, was, on the 1st November last, 389, and included everything relating to electric lighting and the distribution of electricity, as well as some miscellaneous patents.

PROPOSED EXTENSION OF THE TELEGRAPH IN SHETLAND.—A long correspondence has taken place between Mr. Garriock, of Reawick, Shetland, Mr. Laing, M.P., and the Postmaster-General, with reference to the proposal to extend the telegraph system to the principal fishing stations on the west side of Shetland, the curers and fishermen there being under great disadvantage, particularly in the herring-fishing season, when some hundreds of boats from ports on the east and west coasts of Scotland are engaged in that industry. The Post Office and Treasury decline, says the *Scotsman*, to extend the line from Lerwick to Walls and Reawick unless a guarantee

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be given by the inhabitants of £255, for seven years, a total guarantee of over £1,700; while Mr. Garriock maintained that the above line can be constructed for less than £1,000. It having been proposed to get a guarantee out of the herring brand fund instead of a money grant, Mr. Laing has communicated with Lord Rosebery, who writes that he has forwarded the communication to the new Fishery Board.

An Electric Train-starting Clock.—A very ingenious electric clock for use in railway stations has been recently exhibited in Boston. It gives automatically the signals for starting trains at the proper times, and it is automatically regulated at noon each day by electric impulse from some astronomical station. Though the details of the apparatus are rather complicated, the principle is simple. The mechanism for giving the signals shows two discs, each pierced with 1,440 holes, arranged in spirals of 24 turns, with 60 holes in each turn. Small metallic pegs are inserted in the holes corresponding to any given minute and hour, and the contact of these with an electric conductor allows passage of the current for the signal. When any change is made in the time of starting trains the pegs are shifted. One, two, three, or more successive and different signals can be given for each train. It is proposed, says *The Times*, to connect all the stations of a railway with the main office, so that signals for starting trains will be given from a single apparatus.

Human Hair for Carbon Filaments.—Mr. William Stanley, jun., of Bergen, New Jersey, U.S.A., has recently patented, through his agent, Mr. J. Wetter, a mode of preparing human and other hair, preferably human, for making carbon filaments for incandescent lamps. In his patent he remarks:—"It has been found that the hair of the human head is superior to that of the lower animals for making carbons for the purpose indicated, and that the hair of Chinamen gives the most satisfactory results. This is probably due to the circumstance that the hair of the Chinese, so far as it has been examined, is coarser than that of most races, and is remarkably straight and uniform in cross section." But how about the sacredness of the Chinaman's pigtail? Perhaps Mark Twain's heathen Chinee might be got to part with his tail for a consideration, but we doubt if any Chinaman with the least atom of self-respect would do so, not even to become the means of thereby enlightening the world after a celestial manner. The number of Mr. Stanley's patent is 2,660, June 7, 1882.

A Dictionary of Electricity.—This is the title of a work by Mr. Henry Greer, which is published by the College of Electrical Engineering, 122, East Twenty Sixth-street, New York, at the price of two dollars. As we have not seen a copy of the work in question we cannot speak as to its merits, but it appears to have been thought well of by Edison, Brush, and other authorities. For the benefit of our American friends who are good enough to send us slips of paper containing announcements of new works, &c., with appetising promises of future advertisements if we notice the same, we may remark that we are not, and never have been, in the habit of giving an opinion upon anything we have not seen and tested for ourselves, or of which we have not trustworthy information. If they will send us the books, instead of the slips of paper, they will put us in a better position to give an opinion. As regards the promises of advertisements, there may be English papers who will put the notices in with the hope that the promises as to future advertisements will be fulfilled—who will, in fact, sell their literary soul for a little money. We do not believe there are many such. However that may be, we must beg our transAtlantic correspondents of the class above-mentioned to keep such blandishments for those who appreciate them, and not to cast their pearls before such swine as ourselves.

Electric Lighting by Accumulators.—The offices of Messrs. Foster and Braithwaite, 27, Austinfriars, E.C., are now lighted by means of Lane-Fox incandescent lamps, fitted on the gas standards originally in use. The number of lamps employed at present is 24, of 20 candle-power each; it is intended, however, to increase this number to 30. The current is supplied by 25 Faure-Sellon-Volckmar accumulators, constructed by the Electrical Power Storage Company, of Great Winchester-street-buildings, E.C. These are fitted up in the cellar beneath the offices, and are charged by means of a small No. 2 Brush dynamo machine, driven by a 1 h.-p. Otto gas engine erected in the same cellar. According to the representative of the Electrical Power Storage Company, the E.M.F. of each of these cells is 2·15 volts, whilst they give a current equal to 800 ampere-hours when fully charged. The installation is a complete one of its kind, and includes all necessary switches, each light being readily turned off or on independently of the others, and one of Ayrton and Perry's ammeters. The lamps gave a very steady and good light when we saw them on Wednesday evening, and altogether the installation seems to have been carefully carried out. There appears to be a concensus of opinion amongst Messrs. Foster and Braithwaite's *employés* in favour of the new light over that of gas, mainly on account of the increased purity of the atmosphere in which they have to work.

Overhead Wires and Public Safety.—Unless something unforeseen occurs, the arrangements of our towns and cities, the structure of our houses, the very habits of our daily life, says the *Builder*, are likely to be transformed by this subtle energy. To this end the companies are silently but rapidly working. And each day that they are so allowed to work not only stretches tons of additional wires over our heads, but goes to create at least the presumption of a vested right in the use of our housetops by the telephone companies. Let us suppose matters to go on just as they are now doing till the time when the earliest wires attain their natural period of durability, and that then, within a few weeks, we have a dozen cases of slaughter in the streets by the natural agency of the decaying wire. What will be the public excitement? What the demand for the immediate removal of the source of danger? What the cost of the hurried change? What the inconvenience? What the demands for compensation, to be provided by a legislature, and paid by a public, that took no heed of the growth of the mischievous and threatening mode of putting house in communication with house, until it was too late? The confusion will be something altogether without precedent. It is thus not only in the behalf of the one client for whom the scientific journalist holds a general retainer (viz., the public), but also on behalf of the telephone companies themselves, that we desire to join in the remonstrances now made, and to plead for the public safety.

Electric Lighting from a Business Point of View.—We take the following from Matheson and Grant's "Engineering Trades Report" for the last half year:—"Electric lighting is only slowly taking a place as a substitute for gas, the recent legislation in regard to the lighting of towns having tended in many cases to embarrass rather than simplify the inauguration of a new system. Applications for parliamentary powers have, however, been made by so many corporations and joint-stock companies that the coming year will doubtless clear away many of the difficulties, financial

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and legal rather than scientific, which at present seem to stop the way. Meanwhile, the real truth in regard to the numerous undertakings for which capital was so freely subscribed a year ago is becoming manifest; and, as we ventured to point out in our July Report, the unremunerative nature of those companies which commenced business burdened with large capital already paid away for doubtful patent-rights, and unavailable, therefore, for the genuine expenses of working, will discredit really sound enterprises when they arise. The sale of subsidiary rights and patents is much more profitable to promoters than the carrying out of actual works, and the credulity of investors is even at the present time being taken advantage of for inventions practically valueless with an audacity which deserves exposure. The manufacture of the apparatus and its installation afford employment to engineers, but to them also it is interesting to note that the light is coming into increased use, not only for the carrying on of public works such as harbours, mines, and building operations at night, but as superseding gas in machine shops and factories."

The Telegraph and Steam Engine.—Mr. Courtney, M.P., in presiding at the annual meeting of the Royal Cornwall Geological Society at Penzance this week, referred to the introduction of the electric telegraph and the invention of the steam engine, by which electricity and steam had been made our slaves in almost all the operations of life. No doubt, Mr. Courtney is reported to have said, these were most remarkable applications, and we, in the present day, were greatly indebted to them; but, at the same time, he was bound to say that, in his opinion, we might overrate the debt. The conveyance of news by the telegraph was insignificant, if the news itself were not of importance. As to the diminution of toil which steam effected in supplying our wants, it depended very much on the use we made of it, and how far that did or did not confer a benefit on mankind. Was it a fact that, owing to the introduction of steam, the labour which was necessary for the subsistence of the multitude had been in any sense diminished, and the ragged edge of pauperism which surrounded the borders of society had in any sense disappeared? We might derive either of two advantages from the introduction of steam—we might either make life less toilsome while maintaining the mass of it as it was, or keep up the toil of life while increasing the mass, and he was afraid the result of the discovery of steam power had been an increase in the number of human beings rather than an improvement in the quality of life. He was, indeed, more disposed to reverence science for its educational than for what he might call its economic advantages, for the way in which it elevated the mind of man rather than for its ability to enable more men to live on the same low level on which men lived before.

On the Electrification of Air.—The following note has been presented to the Academy of Sciences, Paris, by M. Mascart:—At one of the meetings of the International Congress on Electrical Units, recently held in Paris, Sir W. Thomson called attention to the scientific interest which would attach to continuous observations on the electrification of the lower layers of the atmosphere, by determining the potential in a limited volume of gas taken from the surrounding air and removed from the action of foreign electrical masses. I endeavoured to ascertain, by experiment, how a quantity of air thus isolated preserves its electrification, in order to define the conditions necessary for continuous observation. The air of the amphitheatre of the Collége de France, which represents in round numbers a cube of 9 to 10 metres per side, was electrified by the discharge of a Leyden jar during 10 seconds through a conducting flame. An electrometer, placed in the room, was connected with a receiving flame placed at about 8 metres (about 26ft.) from the place of discharge, and 1·50 metres from the floor. As soon as the discharge began the electrometer was affected. The deflection was at first accompanied by a series of oscillations of great amplitude, then it increased in more regular manner, attained a maximum after 10 to 15 minutes, and afterwards slowly decreased. The primary large oscillations appeared to be due to a direct action of layers of electrified air on the conducting wires of the electrometer which were too near them. To eliminate this cause of error, the electrometer was placed in a neighbouring room, connection with the receiving flame being established by a wire which traversed the partition. In this case the effects were more regular; the maximum deflection was again attained in about a quarter of an hour, then it decreased slowly, following a law which the form of the curb clearly shows to be an exponential, as for caloric radiation. At the end of two hours, the potential was still 1-20th of its maximum value. A series of oscillations of small amplitude were again perpetually appearing, above all during the first part of the time, and these oscillations were enlarged on opening a door, even for a very short time, or when an observer crossed the room at several metres distance from the receiving flame. These phenomena are easily explained if we admit that the electrification remains adherent to the layers of air which have been directly in contact with the flame during the discharge. The electrified gases rise by reason of their high temperature, then are set in motion and disseminated after the manner of fumes, until they are uniformly distributed in the atmosphere of the room; the deflection of the electrometer is then nearly at its maximum. As to the disappearance of the electricity, it is occasioned either by exchange with the outer air, or by the receiving flame itself, which continuously neutralises the surrounding electricity, or by contact of the air with the sides of the room. The loss should be diminished when the movements of gas due to the presence of the flames are suppressed. This is shown by the experiment of discharging the jar by a sharp point, and replacing the receiving flame by a flow of water. The needle of the electrometer is still deflected directly after the commencement of the discharge, but it then remains stationary for some time, reaches its maximum deflection a little later, and returns to zero more slowly. At the end of an hour the loss was not more than two-thirds; it would, doubtless, have been much slower in an absolutely calm atmosphere. An indirect proof of this is furnished by watching the air enclosed in a room, having no means of communication with the outside but by the usual draughts through the doors and windows. We almost always find here electricity of the same sign as that of the outer air, for the opening of a window is sufficient to greatly increase the indications of the instrument. The result of these experiments is, that to examine the lower layers of the atmosphere it is sufficient to determine the potential in a room a few metres in area, the walls of which should be formed by a metal wirework with large meshes in connection with earth, in order to eliminate the action of external electrical objects. The exchange of gas with the atmosphere, however feeble the wind might be, would suffice to compensate for the loss produced by the walls and by the collecting apparatus (flame or flow of water), and to give to the electrometer a constant potential proportional to the electrification of the surrounding air. This potential will be quite different (more often than not of contrary sign) to that obtained by the usual methods.

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ELEMENTARY ELECTRICITY.

V.

On the Energy of an Electrified System.

If a half-hundredweight be carried to the top of a mountain 1,000ft. in height, the work done against gravity will be 56,000 foot-pounds, and the height of the mountain will not be sensibly affected by the presence of the half-hundredweight on its summit. Generally, if w lbs. be raised to a height of h ft., the work done against gravity will be $w\,h$ foot-pounds.

Similarly, if Q units of electricity be brought from the earth to a place where the potential is V, and if this potential be supposed unaffected by the presence of the Q units of electricity, a supposition which we may make if Q be sufficiently small, then the work done against electrical forces will be Q V ergs, and this, therefore, will represent the *potential energy* due to the charge in its new position.

If a quantity of bricks, say, w lbs., be piled up on a horizontal plane so as to form a solid cylindrical tower whose height is h ft., a certain quantity of work will be done against gravity in raising the bricks into their position; but this will *not* be equal to $w\,h$ foot-pounds, for it is only the last course of bricks which is raised through the full height of h feet (neglecting the thickness of the bricks). If we consider the first and last courses together, we see that the *average* height through which they are raised is $\frac{1}{2}h$ feet, and, similarly, if we take the second and last but one, the third and last but two, and so on. Hence the work done in raising all the bricks into their positions is the same as if they were all raised through a height of $\frac{1}{2}h$ ft.; that is, to the height of the centre of gravity of the pile. Hence, the work done in raising the bricks into their positions is $\frac{1}{2}w\,h$ foot-pounds.

If the height of the tower be doubled, its base remaining the same, the weight of bricks will also be doubled, so that the product $w\,h$ will be increased four-fold, and, generally, the work done in raising the bricks into their positions will be proportional to the *square of the height* of the tower, if the area of the base be given. It is this law of increase which partly accounts for the great expense of erecting lofty buildings.

The case is precisely similar when a conductor is charged. Thus, if the conductor be initially uncharged and at potential zero, and if Q units of electricity be communicated to it, whereby its potential is raised to V, in virtue of its own charge, and of that alone, the work done in charging the conductor, and the potential energy of the system when charged, will be $\frac{1}{2}$Q V ergs. For, if we divide the charge into a very great number of equal portions, or "elements," the first element on entering the conductor finds it at zero potential, and no sensible amount of work has to be done in order to bring this element from the earth to the conductor. A little work will have to be done on the next element, and a little more on the third, and so on, but it is only the last element which enters the conductor when it is at potential V; and, since the potential of the conductor depends only on its own charge, the potential will, as explained below, at each instant be proportional to the charge which the conductor then possesses, and, therefore (as in the case of the tower of bricks), the *average difference of potential* through which the several elements of the charge are raised will be $\frac{1}{2}$V. Hence, the work done in charging the conductor will be $\frac{1}{2}$Q V ergs.

The *capacity* of a conductor was defined as the number of units of electricity required to raise it to unit potential, and this is a quantity which depends only on the form and dimensions of the conductor, and on its geometrical relations to other conductors, provided that the dielectric remain unhanged. Hence the potential to which a conductor will be raised by its own charge will be proportional to that charge, so that, if C denote the capacity of the conductor, Q its charge, and V the potential to which it is raised thereby, then

$$V = \frac{Q}{C}.$$

Thus, if the charge of a conductor be doubled, its potential will be also doubled, and the energy will be increased fourfold. Generally, the energy of a conductor which depends on its own charge only will be proportional to the square of its charge. If E denote the *energy* of a charged conductor when *isolated*, that is, removed from the inductive action of all other bodies, we have the following relations:—

$$E = \frac{1}{2}Q\,V = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}C\,V^2,$$

so that we can express the energy in terms of the *charge* and the *potential*, or of the *charge* and the *capacity*, or of the *capacity* and the *potential*.

There is one other case to be considered. A tower might be built on the top of a mountain, but so lofty that its height could not be neglected in comparison with that of the mountain. Suppose that the height of the mountain above the brickfields is k ft., the height of the tower from base to summit h ft., and the weight of bricks employed w lbs. (The tower is supposed to be built without foundations.) Then the work done in lifting the bricks to the top of the mountain will be $w\,k$ foot-pounds, as in the first case considered, and the work done in lifting the bricks from the mountain top into their positions in the tower will be $\frac{1}{2}w\,h$ foot-pounds, as in the second case, so that the whole amount of work done in raising the bricks into their proper positions will be $w\,k + \frac{1}{2}w\,h$ foot-pounds, that is, $w\left(k + \frac{1}{2}h\right)$ foot-pounds. This result might have been obtained with equal readiness from the consideration that the height of the *centre of gravity* of the tower above the brickfields is $k + \frac{1}{2}h$ feet, whence the work done against gravity in raising the bricks must be $w\left(k + \frac{1}{2}h\right)$ foot-pounds.

Now, suppose that a conductor, though uncharged, is maintained at a potential V_1 by charged bodies in its neighbourhood, and that a charge of Q units of electricity is communicated to the conductor. Let V_2 be the potential to which the conductor would be raised by this charge alone. Then its final potential will be equal to $V_1 + V_2$. The first element of electricity which enters the conductor will be raised to potential V_1, and the last element to potential $V_1 + V_2$, the *average* difference of potential through which the electricity is raised being $V_1 + \frac{1}{2}V_2$, so that the work done in charging the conductor will be $Q\left(V_1 + \frac{1}{2}V_2\right)$ ergs, or $Q\,V_1 + \frac{1}{2}Q\,V_2$ ergs. The case is precisely similar to the tower just referred to, V_1 corresponding to the original height of the mountain k, which is independent of the presence of the bricks, and V_2 corresponding to the height of the tower h, which depends only on the bricks.

If C denote the capacity of the conductor in the position it occupies, *i.e.*, the charge which would raise it to unit potential if the other conductors were present but not separately charged, then, as before, $V_2 = \frac{Q}{C}$, and the second term in the expression for the work may be expressed in terms of the charge and capacity, or the potential and the capacity.

Instead of considering a tower of bricks, we might have drawn an illustration from a cylindrical vessel, into which water is pumped from a lake, the height of the surface of the water in the vessel depending on the quantity present. If the bottom of the vessel be on a level with the surface of the water in the lake, and the vessel be filled to the height of

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h feet, with w lbs. of water, the average height to which the water is raised will be $\frac{1}{2}h$ feet, and the work done in pumping, or the energy of the raised water, will be $\frac{1}{2}wh$ foot-pounds.

If we suppose the height of the cylindrical vessel to be unlimited, and the height to which it may be filled with water limited only by the power of the pump or the strength of the vessel itself, we have a strict analogy with an electric conductor, a Leyden jar for instance, in which the lake corresponds to the earth, the pump to the electric machine, and the strength of the vessel to the strength of the dielectric to resist disruptive discharge. It may be remarked here that the *capacity* of a conductor has no necessary relation to the amount of electricity which can be put into it if a sufficiently powerful electric machine be employed. This is limited by the strength of the dielectric, while the capacity depends simply on number of units of electricity required to charge the conductor to unit potential, and would be the same even if the dielectric were so weak as to break down before the unit of potential were attained. If we say that a vessel can contain just a pound of water at 4°C, this serves practically to determine the volume of the vessel, for an enormous pressure would be required to increase the quantity of water by one-tenth per cent.; but the statement that a vessel can contain a pound of air at 0°C gives no idea of the the size of the vessel, unless the pressure of the air be also stated. The amount of air at 0°C which would fill the vessel to standard pressure is perfectly definite, and might be called the *capacity* of the vessel for *air*. Electric capacity is analogous to this.

Now, suppose we define the capacity of the cylindrical vessel, which, as above stated, is unlimited in height, as the number of pounds of water required to fill it be a height of 1ft. The capacity will then depend on the sectional area only. If c denote the capacity as thus defined, and if w lbs. of water be pumped into the vessel, and the surface be thereby raised to a height of h ft., we have $w = c\,h$. Also the work done in raising the water against gravity will be $\frac{1}{2}wh$ foot-pounds, and this will, therefore, be the potential energy of the raised water. Let it be denoted by e. Then we have

$$e = \frac{1}{2}wh = \frac{1}{2}\frac{w^2}{c} = \frac{1}{2}ch^2.$$

Now, let a second vessel of the same capacity be taken, and let the two vessels be connected by a tube at the bottom of each, and suppose that the second vessel is empty. On opening the communication between the two, one-half of the water in the first vessel will run into the second, the height of the surface in each will finally be $\frac{1}{2}h$ ft., and the energy of the water in each vessel, e', will be represented by

$$e' = \frac{1}{2}\cdot\frac{w}{2}\cdot\frac{h}{2} = \frac{1}{2}c\left(\frac{h}{2}\right)^2 = \frac{1}{4}e.$$

Hence the energy of the whole amount of water in the two vessels will be equal to $\frac{1}{2}e$, or only one-half of that which it possessed when it was all contained in one vessel. The other half of the energy was dissipated as heat, &c., when the water flowed through the pipe and dashed itself against the sides of the empty vessel.

If a third vessel of the same capacity be connected with the other two there will again be a flow of water, a lowering of the surface, and a further dissipation of energy. The energy of the water in each vessel will be $\frac{1}{9}e$, and the whole energy $\frac{1}{3}e$. Similarly, if the water be divided between n equal vessels, the whole energy will be reduced to $\frac{1}{n}e$. We must notice, however, that *the quantity of water* remains the same. If n be made indefinitely great the final condition is the same as if the water were allowed to flow back into the lake, and the energy is reduced to zero, *but the water*, of course, *remains*.

The case is similar when we have a Leyden jar of capacity C, charged to potential V with Q units of electricity. Denoting the energy of the charge by E, we have

$$E = \frac{1}{2}QV = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2.$$

Now, suppose the inner and outer coatings of the jar connected with those of an equal, but uncharged, jar. The charge will then divide itself equally between the two, the potential of each will be reduced to $\frac{1}{2}V$, and the energy of each to $\frac{1}{4}E$, so that the whole energy of the system will be $\frac{1}{2}E$, while the remaining $\frac{1}{2}E$ units of energy will be dissipated in the spark which occurs.

If a third equal jar be now connected with the other two, the charge will be equally divided between the three, and each jar will then possess one-ninth of the energy possessed by the first jar before discharge, so that the energy possessed by the three jars together will be only $\frac{1}{3}E$, the rest of the energy having been dissipated in the sparks.

If the number of jars be still further increased the energy will be correspondingly diminished, so that when the charge is divided among n equal jars, its energy will be reduced to $\frac{1}{n}E$.

But throughout all these changes, associated as they are with the dissipation of the energy of the charge, the quantity of electricity with which we have to do remains absolutely constant, viz., Q units. Thus, work is done by the system, and electrical energy is transformed into heat, &c., but the quantity of electricity remains unchanged. When heat is employed in doing work, we not only have a general lowering of temperature, but a part of the heat, equivalent to the work done, is actually consumed in the process, being transformed into some other form of energy, and ceasing altogether to exist as heat. This is the case, because heat *is itself energy*, and nothing else. Therefore, we do not say that heat *possesses* energy, but heat *is* energy. The case of electricity, however, is very different. The electricity falls in potential, but none of it is lost or transformed into anything else. The charge remains unchanged. The analogy is to be found in the case of water or other heavy matter which does work as it falls from a high level to a low level, though the quantity of matter remains absolutely unchanged. Thus, we may say that water *possesses* energy in virtue of its situation relative to the earth, but we cannot say that water *is* energy. Similarly, electricity *possesses* energy in virtue of its potential, and can do work as its potential falls, but electricity itself *is not* energy, for however much work it may do, the quantity of electricity remains unchanged.

As the energy due to a charge of electricity does not depend on the charge alone, but on its mode of distribution, it is natural to inquire where this energy resides. Suppose that two equal flat plates, A and B, are insulated, and charged, the one positively, and the other negatively, but with numerically equal charges. Let them be placed opposite each other, like the plates of an air condenser, and very near together, so that there is only a thin plate of air between them. The potential of A will be positive, but very small, because the negative charge on B produces a negative potential at A, which is numerically not much less than the positive potential due to the charge of A itself. Similarly, the potential of B will be numerically small, but negative. The charge of each will increase the energy of the system, since the positive charge is at positive potential and the negative charge at negative potential.

Although the attraction between the charged plates may

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be very great, yet not much work can be done by the charges moving up to and neutralising one another, because there is such a small distance through which they can move. Hence we should expect the expression for the energy in terms of the charge and potential of each plate to be small; which is the case. Now let the plates be removed to a greater distance from one another. The energy will be increased by the work done in separating the plates in the same way as the energy of the earth and a raised weight is increased when the weight is raised to a greater height, even though the attraction between them diminishes. Thus, the greater the distance between the plates the greater will be the energy of the system and the work done by the electric forces if they are allowed to coalesce, and the greater will be the numerical value of the potential of each, because it will be less affected by the opposite charge on the other, so that the expression for the energy of each plate in terms of its charge and potential will increase, as, of course, it should. Throughout the process the dielectric between the plates is in a state of strain, and though this strain is diminished as the plates recede from one another, the quantity of the dielectric which is exposed to it is increased in a greater ratio, so that, on the whole, the *energy* due to the strain is *increased*. That such a state of strain exists appears from the fact that, if the charges be sufficiently increased, a spark will pass producing rupture in the dielectric. If the dielectric be a solid, like the glass of a Leyden jar, the passage of the spark produces a permanent rupture in it. Thus, the glass of a Leyden jar is sometimes pierced by overcharging the jar, and the jar thereby rendered worthless. Now, before a hole can be blown through a piece of glass the glass must be in a state of strain, and it is only when the stress to which the glass is exposed exceeds its ultimate strength that it will give way. Hence, we infer that when the dielectric does not give way, it is still in a condition of elastic strain, the amount of which depends on the strength of the charge. It is the energy due to this elastic strain which constitutes the energy of the electrified system.

Hence the dielectric plays a much more important part than the conductor, if we may speak of relative importance when each is essential. In fact the conductor simply serves to transmit the electricity to the surface of the dielectric, and it is the dielectric which is the theatre of all electrostatic action. The conductor is simply an electrode which has performed its office as soon as the question belongs to *electrostatics*, the conductor itself being entirely unaffected by any electrostatic action. We may regard a conductor in its normal state as filled with the electric fluid, which is *perfectly incompressible*. When the conductor is positively charged, more electricity is forced into it through its electrode, but, since it is already full of incompressible fluid, this can only happen by some of its electricity being squeezed out through the surface of the conductor, and thus made to press upon the dielectric, the conductor remaining altogether unaffected. But the dielectric, like the conductor, is full of the electric fluid itself, but, unlike the conductor, it cannot allow the fluid to pass through its substance, so that as the charge is squeezed out through the surface of the conductor into the dielectric, the fluid in the dielectric is pushed outwards to make room for it, and the whole dielectric is thereby thrown into a state of strain, which diminishes as the distance increases, but which must be continued till another conductor is reached, which can protect the dielectric beyond it, by allowing free displacement of electricity through its own substance. When such a conductor is reached, electric displacement takes place across its surface, electricity from the dielectric being, as it were, squeezed into the conductor through its surface, the surface thus becoming negatively charged, while an equivalent amount must leave the conductor and go into the earth or elsewhere, otherwise it will be squeezed out of the conductor at the opposite face into the dielectric, and the state of strain will then be propagated still further. Thus, if a charged body be surrounded by a conductor which is put to earth, no electric action will be communicated beyond this conductor; but if the conductor be simply a metal shell, insulated and uncharged, the stress will be continued on the other side. Hence, the use of wire cages connected with the earth, &c., for the protection of intruments from electrical actions.

It will also be seen that all electric displacements must take place in *closed circuits*. In the discharge of a Leyden jar the circuit is completed on the one hand by the discharger connecting the coatings, and on the other by the glass of the jar, across every layer of which there is a displacement of a quantity of electricity equal to that which appears in the spark.

Also, according to this view, a conductor is positively electrified when electricity is squeezed out of its surface into the surrounding dielectric, and is negatively electrified when electricity is squeezed from the dielectric into the surface of the conductor.

MAGNETIC FORCE AND CURRENT.—III.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 152.)

Coming now to the electro-magnetic problem, we have two distinct things to do. First to prove the properties stated in Arts. I. and II., pp. 6 and 32, as applied to the system of vectors therein defined, quite apart from any physical application (this will be comparatively easy with the aid of (4) and (3) above, which are the characteristic equations of the potential function, (3) giving ρ in terms of the second derivatives of P, and (4) giving P in terms of ρ and distances), and next, to show that magnetic force and electric current belong to the system.

Let A be any vector of no convergence, to be imagined by the fluid analogy. Its components will be represented by A_1, A_2, A_3, and similarly for other vectors. Derive from A its curl B. The fundamental relation between A and B is that the line-integral of A round any closed curve = amount of B passing through it. The components of B are expressed in terms of those of A by means of the equations. (Theorem II., p. 56)

$$B_1 = \frac{dA_3}{dy} - \frac{dA_2}{dz}; \quad B_2 = \frac{dA_1}{dz} - \frac{dA_3}{dx}; \quad B_3 = \frac{dA_2}{dx} - \frac{dA_1}{dy}. \quad . \quad (5)$$

If we differentiate B_1, B_2, B_3 with respect to x, y, z and add, we find that B has no convergence, for the sum is zero. Similarly, derive from B its curl C, and from C its curl D, and so on. They are all vectors of no convergence, simply because the first one, A, has none. Now the equations for the components of C, similar to (5) are

$$C_1 = \frac{dB_3}{dy} - \frac{dB_2}{dz}; \text{ \&c.}$$

In this last, substitute the values of B_1, B_2, B_3 from (5), and it becomes

$$C_1 = \frac{d}{dy}\left(\frac{dA_2}{dx} - \frac{dA_1}{dy}\right) - \frac{d}{dz}\left(\frac{dA_1}{dz} - \frac{dA_3}{dx}\right).$$

Re-arranging the terms, and adding and subtracting $\frac{d}{dx} \cdot \frac{dA_1}{dx}$, this becomes

$$C_1 = -\left(\frac{d^2A_1}{dx^2} + \frac{d^2A_1}{dy^2} + \frac{d^2A_1}{dz^2}\right) + \frac{d}{dx}\left(\frac{dA_1}{dx} + \frac{dA_2}{dy} + \frac{dA_3}{dz}\right).$$

Here we at once recognise the quantity in the second ( ) to be the convergence (with sign changed) of A. But A has no convergence, so we are reduced to the quantity in the first ( ). Compare with Equation (3) above. For A_1 write P, and for C_1 write ρ. Since (4) is the solution of (3), or P the potential of ρ, therefore in the present case A_1 is the potential of C_1. Similarly we shall find A_2 to be the potential of C_2, and A_3 of C_3. Now compound A_1, A_2 and A_3, and we obtain the vector A. Similarly compound C_1, C_2 and C_3, and we get the vector C. Therefore, A is the *vector*-potential of C.

Similarly B is the vector-potential of D, and so on.

Thus, whilst the operation of curling carries us one step down the scale, that of finding the vector-potential carries us two steps up. Which we may express, curl (curl A) = C, or

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$(\text{curl})^2 A = C$; also A = potential C, therefore curl curl potential C = C.

We may now show that the operations curl and potential are commutative, or curl potential C = potential curl C. For

B = potential D; just proved.
= potential curl C, by definition of D.
= curl A, by definition of B.
= curl potential C; just proved.

Therefore, B = potential curl C = curl potential C.

We may thus find any one of the series from the next following by either first going up two steps by the potential and then down one by curling, or else by first going down one step and then up two. *E.g.*, given C, to find B, we may go up to A and down to B, or down to D and up two steps to B.

This roundabout method may be replaced by a single operation—very complex, however, though for single elements easily enough understood; that is to say, we may find B direct from C without reference to the other vectors. The operation has no name; since its effect is the inverse of curling, we might denote it by $(\text{curl})^{-1}$, just as we might denote vector-potential by $(\text{curl})^{-2}$, thus indicating its property.

The vector-potential of an element of C, say c at a point Q distant r therefrom, is $a = \frac{c}{4\pi r}$ directed parallel to c. (Small letters when referring to elements.) Let the direction of c be parallel to z. Then

$$a_1 = 0; \qquad a_2 = 0; \qquad a_3 = \frac{c}{4\pi r}$$

express the components of a at Q. Find the curl of a by equations (5) above, thus,

$$b_1 = \frac{c}{4\pi}\frac{dr^{-1}}{dy} = -\frac{cy}{4\pi r^3}; \; b_2 = -\frac{c}{4\pi}\frac{dr^{-1}}{dx} = \frac{cx}{4\pi r^3}; \; b_3 = 0.$$

Now let h be the perpendicular from Q on to the axis of the current (the axis of z), and let the x-axis be parallel to h, so that $y = 0$ and $x = h$, the origin being at the element. Since $b_3 = 0$, b is in the plane of x, y, and since $y = 0$, therefore $b_1 = 0$, and

$$b = \frac{ch}{4\pi r^3} \text{ perpendicular to } r \text{ and to } h \quad . \quad (6),$$

with right-handed rotation about the axis of the current when we look along it the way the current is going.

The lines of b are, therefore, circles about the axis of c in planes perpendicular to it, and the strength of b varies inversely as the square of the distance from c, and is at the same time proportional to $\frac{h}{r}$, which is the sine of the angle between r and the axis of c. Every element of c must be understood to produce such a system b, and the vector-sum of the whole will give the complete value of B. Thus,

$$B = \text{v.}\Sigma\frac{ch}{4\pi r^3} = \text{v.}\Sigma - \frac{c}{4\pi}\frac{dr^{-1}}{dh} \quad . \quad . \quad . \quad (7)$$

In an exactly similar manner A may be expressed in terms of B, or C in terms of D. Thus, to express A in terms of B, change B into A and c into b in (7).

[The above method of expressing $(\text{curl})^{-1}$ C was obtained by finding the curl of the vector-potential of an element of C. We shall get exactly the same result by finding the vector-potential of the curl of an element of C. Thus, take a cylindrical element, of length ds, circular section πa^2, radius a. Current-density c, directed parallel to axis ds. The surface-curl of c is (see p. 8) of strength $\frac{c}{\pi a^2}$ directed in circles about the axis on the curved portion of cylinder.

Now, the vector-potential of a unit circle of radius a, when a is indefinitely small, may be obtained from equation (9), p. 104, by taking the first term only of the series, viz., $\frac{h}{r^3} \times 2\pi a^2 \times \frac{1}{2} = \pi a^2 \frac{h}{r^3}$.

Or, without making use of the equation (9) for a finite, let $\frac{a}{r}$ in the previous equation (6), p. 103, be indefinitely small, and expand $\frac{1}{\rho}$ by the binomial theorem, thus $\frac{1}{\rho} = \frac{1}{r} + \frac{ha\sin\phi}{r^3}$, therefore we get

$$\int_0^{2\pi} \frac{a\sin\phi}{\rho}\, d\phi = \int_0^{2\pi} \frac{ha^2}{r^3}\sin^2\phi\, d\phi = \pi a^2 \frac{h}{r^3}$$

as before. Multiply by $\frac{c}{\pi a^2}$ and we get the required vector-potential of curl of c, viz., $\frac{ch}{r^3}$, which, when divided by 4π to suit our present definition of potential, agrees with (6).]

At a distance r from a small plane closed curve great compared with its linear dimensions, its form is immaterial. The vector-potential is $\frac{h}{r^3} \times$ area, directed perpendicular to h and r.

We are now able to make another step. We proved before that when a vector has no curl anywhere, the vector itself is the space-variation of P, and P is the potential of the negative convergence of the vector. Now, our vectors A, B, C ... have curl, but not necessarily everywhere, and by Theorems II. and III., pp. 56-7, a vector may be derived from a scalar potential function wherever it has no curl. But A, B, C have no convergence anywhere, so the scalar potential cannot be found in the same manner for a vector which has curl in some parts of space and not in others, as for a vector which has no curl anywhere, (in which case (4) is the solution). To find the nature of the scalar potential for a vector of no convergence, let the vector c be confined to the boundary of a small plane area dS, *i.e.*, let c circulate round the closed curve bounding dS, and be nothing everywhere else. The vector b, of which c is the curl, must be derivable from a scalar potential in all space except in c itself. Now, we know the vector-potential of c, viz., $a = \frac{ch\, dS}{4\pi r^3}$ perpendicular to r and h, where r is the straight line from c to the place where a is measured, and h the perpendicular from the latter on to the axis of c, and that its three components are

$$a_1 = \frac{c}{4\pi}\frac{dr^{-1}}{dy}dS; \; a_2 = -\frac{c}{4\pi}\frac{dr^{-1}}{dx}dS_1; \; a_3 = 0.$$

From these derive b by means of equations (5). Thus

$$b_1 = \frac{c}{4\pi}\frac{d}{dx}\frac{dr^{-1}}{dz}dS; \; b_2 = \frac{c}{4\pi}\frac{d}{dy}\frac{dr^{-1}}{dz}dS;$$

$$b_3 = -\frac{c}{4\pi}\left(\frac{d^2r^{-1}}{dx^2} + \frac{d^2r^{-1}}{dy^2}\right)dS.$$

Here consider b_3. Since $\frac{c}{4\pi r}$ is the scalar potential of a quantity of "matter" c collected at the origin, we have, by equation (3)

$$\frac{c}{4\pi}\left(\frac{d^2r^{-1}}{dx^2} + \frac{d^2r^{-1}}{dy^2} + \frac{d^2r^{-1}}{dz^2}\right) = 0,$$

everywhere, except at the origin. Therefore, $b_3 = \frac{c}{4\pi}\frac{d}{dz}\frac{dr^{-1}}{dz}dS$. Thus, b_1, b_2, b_3 are the components of the space variation of $-\frac{c\,dS}{4\pi}\frac{dr^{-1}}{dz}$, or, $\frac{c\,dS}{4\pi r^2}\cos\epsilon$, if ϵ is the angle r makes with the axis of c. Call it Ω, then,

$$b_1 = -\frac{d\Omega}{dx}, \; b_2 = -\frac{d\Omega}{dy}, \; b_3 = -\frac{d\Omega}{dz}.$$

This scalar potential Ω is of a singular nature. It varies inversely as the square of the distance, and as the cosine of the angle ϵ. It is evidently not the potential of any collection of matter at the origin, either wholly + or wholly −,

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but we can show that it is the potential of equal amounts of + and − matter indefinitely near each other.

Coat the small plane area dS with matter of surface density m, so that its quantity is $m\,d$S. Its potential at Q, distant r, is evidently $\frac{m\,d\text{S}}{4\pi r}$. Now shift this matter through a small space dz in the + direction along the axis of c. Its potential at the same point Q will now be

$$\frac{m\,d\text{S}}{4\pi}\left(\frac{1}{r} - \frac{dr^{-1}}{dz}\,dz\right).$$

It is therefore increased by the amount $-\frac{m}{4\pi}\,d\text{S}\,dz\,\frac{dr^{-1}}{dz}$ or $\frac{m\,d\text{S}\,dz}{4\pi r^2}\cos\epsilon$. Hence if we coat the surface dS with a quantity $m\,d$S on its + side and with $-m\,d$S on its − side, at the small distance dz apart, the potential of the combination will be $\frac{m\,d\text{S}\,dz}{4\pi r^2}\cos\epsilon$. This becomes identically the same as Ω if we make $m\,dz = c$.

Up to the present the vectors A, B, C have been treated quite apart from whether any of them represented physical quantities, (although they may all be possible cases of velocity distribution in an incompressible fluid). The properties are true whether electric current or magnetic force exist or not. But the last step made, the nature of the scalar potential whose space-variation gives b, brings us into contact with magnetism, and will enable us to fit current and magnetic force into the system. One experimental truth suffices. A small plane electric current and a small magnet produce exactly similar fields of magnetic force, not too near them, when we reckon the + direction of the axis of the magnet to be from its S to its N pole, and that of the current to be such that when we look along the axis in the + direction the current circulates right-handedly about it. If the magnet is very small and also the current area, the similarity exists everywhere except very close to them. We may go *through* a current, but not *into* a magnet. Let the magnet and the current area be indefinitely small, then we may say there is exact similarity at any finite distance.

Now, the magnetic force of a magnet has been proved to be capable of being caused by an imaginary substance, free magnetism, having the same self-repulsive power as the imaginary free electricity, with the same law of force, viz., that of the inverse square, so that the magnetic force at distance r from a charge m of magnetism is $m \div 4\pi r^2$, and if this acts upon a charge m', the repulsion is

$$\frac{mm'}{4\pi r^2}.$$

If, then, our vector c stands for electric current, the "matter" producing the potential Ω must be magnetism, and since the unit of magnetism is expressible in terms of the fundamental units of length, mass, and time, we may define the unit current so that

$$(m\,d\text{S})\,dz = c\,d\text{S},$$

or, strength of pole × length = current × area,

either of which may be called the magnetic moment (of the magnet, or of the current). (Having nothing to do here with the electrostatic system of units, we do not introduce the factor μ for induced magnetisation.)

After having thus made use of magnetism, we might dismiss it for good. In fact, we might replace every magnetised particle by its equivalent electric current, according to Ampère's theory of magnetisation. This theory generally strikes one on first acquaintance as very fanciful, the idea of electric currents flowing round molecules being so difficult to swallow. But it explains magnetism, one mystery takes the place of two; and since we neither know what an electric current nor what magnetism is, it is well to abolish one of them, and there can be no question as to which it should be.

Having now identified C with electric current and B with its corresponding magnetic force, it will be as well to point out the modifications needed to suit the adopted unit magnetic pole and the common definition of potential. They were temporarily discarded in the consideration of the properties of A, B, C, in order to have a uniformity of relations, for otherwise the 4π's would not come in regular order. We must now remember that the force of a magnetic pole is of strength $\frac{m}{r^2}$ at distance r, but that a current c spreading from a centre has strength $\frac{c}{4\pi r^2}$. On the other hand, potential follows the rule $\frac{m}{r}$ or $\frac{c}{r}$ in both cases.

We, therefore, have

$$\text{Vector-potential of C} = \text{A} = \Sigma\frac{c}{r} = \text{v.}\,\Sigma\frac{bh}{4\pi r^3}.$$

$$\text{Magnetic force} = \text{B} = \Sigma\frac{dl}{r} = \text{v.}\,\Sigma\frac{ch}{r^3} = \text{curl A}.$$

$$\text{Current} = \text{C} = \frac{1}{4\pi}\text{curl B}.$$

$$\text{D} = \text{curl C}.$$

From the uniformity of properties of A, B, C, as originally defined, any one of them may be current, the one preceding it being its magnetic force, of which examples were given in Arts. I. and II. The same is, of course, true in the last system, except that the 4π's require shifting occasionally.

There is one more remark to be made. We started with A, a vector of no convergence, and of course C has also none. But we identified C with current. This is admitted to have no convergence in conducting circuits, and in Maxwell's theory it has none anywhere. Much confusion would arise were convergence allowed. All vectors below C are therefore also non-converging, but we have not shown that those above it are. For proof it is sufficient to observe that the vector-potential of a small plane closed current (components given above) is now converging, and that any current system may be built up of such closed currents. This makes the matter square.

In No. IV we shall come to further properties of A, B, and C relating to the kinetic energy of closed currents, and of current-elements.

Erratum.—Page 104, *dele* 2 in denominator.

THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 128.)

When a battery (C A, Fig. 38) has one pole, C, to earth and the other pole, A, is suddenly placed in contact with a long conductor, A B, of considerable electrostatic capacity, (such as a long submarine cable), having its other end, B, insulated, an appreciable time passes between the moment of contact and the wire becoming fully charged to the same potential throughout as the full electromotive force of the battery. The first effect is much the same as if the battery were placed on short circuit. The potential at the pole A, which is attached to the wire, therefore sinks to some point near the datum line. Some of the electricity produced in any indefinitely small fraction of time is absorbed in satisfying the charge in the portions of the surface of the wire nearest the battery, and the rest passing on to the wire beyond. A portion of this, again, is divided in the same way, a part going towards charge and the balance on in current, and, in fact, it is an action in which both the conductive and inductive circuits are both in play at any section. The current at any moment is therefore greater at the part near the battery than further on, for any section receives more electricity than it passes on, otherwise the density of the electricity could not increase. The potential line at any moment is therefore a curve, with its concavity upwards, indicating a decreasing strength of current towards

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the insulated end. As the charging of the wire becomes satisfied a greater proportion of the electricity received at any section is passed on. Thus the curve of the potential line continually becomes flatter until the wire is finally charged up to the full potential, and the potential of the battery pole A has risen again to a potential equal to the full electromotive force of the battery. Thus in the figure, after a very small instant, the curve of potential in the wire would be something like the curve No. 1, the potential at A having fallen from A F to A 1. In the next instant it would be 2, 2, 2; then 3, 3, 3, 4, 4, 4, and 5, 5, 5; and lastly, the wire would be charged to the full potential F G.

If the end A is now placed to earth, the electricity would pour out at A; but as at any part the electricity must be flowing through from any section faster than any electricity is supplied from the parts beyond—for otherwise that section could not become discharged—the current is at any moment stronger near the end to earth than at any part further

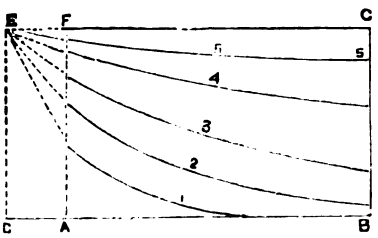

FIG. 38.

remote. The line of potential at any moment must therefore be steeper near the end to earth A than at any part beyond, and the curve of the potential line must, therefore, have its concavity downwards. Moreover, as the end B, the point furthest from the end to earth, has always to give up electricity to the parts nearer to the battery, the highest point of the curve must always be at the end B. Finally, as the wire becomes discharged, the proportion of electricity passing away from any section will constantly approach more nearly to the quantity it receives from the portions beyond it, for the resistance from any section to the end to earth is constantly the same, whilst the potential at every point is decreasing, so that all the currents are becoming less and less and more equal. Thus the potential line at different moments would become flatter, and would take the form somewhat of the curves 1, 2, 3, 4, and 5 in Fig. 39, the last curve indicating a very small current, but much more equal throughout than the state of the currents at the beginning of the discharge. The time of these changes

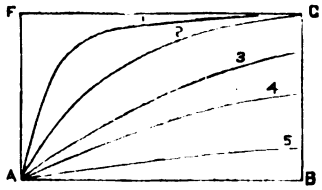

FIG. 39.

in the line of potentials are, no doubt, very different. That is to say, the curve 1 would, perhaps, occur in a minute fraction of a second after contact, but the time occupied between curve 5 and final discharge may be many minutes.

If the end B is to earth when contact is made at A (Fig. 40), then the potential at F will sink instantly to near A, then gradually rise to H. The lines of potential will, as before, for the same reasons, have their concavity upwards, and the curvature will constantly decrease, showing that the current flowing out at B is constantly increasing, whilst that entering at A is constantly decreasing until the line of potential becomes H B, indicating that the current issuing at B has become equal to that entering at A; or, in fact, the line has become fully charged, and the current is constant and permanent throughout the circuit. This is the state, called by the French "*l'etat permanent*," and the charge in the wire represented by the triangle A H B is called by some electricians the "dynamic" charge, in contradistinction to the charge in a wire with the end insulated, for which the term static is reserved. When the wire, having arrived at the permanent state, has the end A put to earth (Fig. 41), then a portion of the dynamic charge rushes out at that end, A, and the remainder continues to flow out at B. Thus, at the end A a current in the reverse direction to that produced in charging is produced, and is commonly called "the return current." This current is very strong at first, for it has the potential A H for electromotive force, and *no* resistance to oppose it. The current further in the wire must be less than that close to, for the same reasons as those mentioned in the case of the discharge of a wire with the end insulated. The point of maximum potential, which at first is at A (the potential being A H), must eventually be last found in the centre of the line C, for if it came to any other point it would indicate that at the last moment a greater current came out at one end than at the other, whereas it is evident that as long as the highest potential is nearer (as it is at first) to one end A, as a

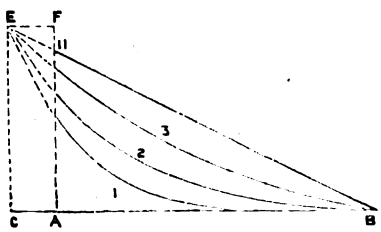

FIG. 40.

greater current is coming out of that end, the currents are consequently constantly tending to equality, and will continue to tend towards equality until they are actually equal, and finally cease at the same moment. Now, as during the greater portion of the time of discharge the currents we have shown is constantly greater at A than at B, it follows that a greater portion of the total charge must pass out at that end. Now, since any electricity at the line of potential at any moment on the B side of the point of maximum potential must pass out at B, and all at the line of potential, that is, at any moment on the C side of the maximum potential must pass out at C, it follows that the path of the point of maximum potential must therefore divide the total quantity of the charge that passes out at A from the total quantity which passes out B. Now, if the path of the point of maximum potential was a straight line from H to C, this would divide the charge into two *equal* parts; but it has been shown that these parts cannot be equal. The path cannot, therefore, be a straight line, but must be a curve

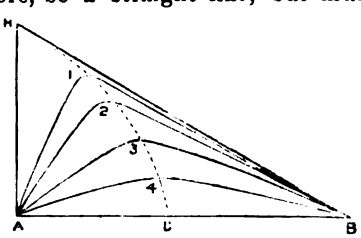

FIG 41.

concave towards A, so as to embrace more of the total charge on the A side of the curve than on the other side. What the exact curve is I am unable to state. Mr. Kempe makes it parabola.

(TO BE CONTINUED.)

NOTICE.—Owing to the great pressure on our columns, we are compelled to leave over a description of the new Elphinstone-Vincent dynamo machine, a notice of the late Mr. Walker, and other matter, for our next issue.

ELECTRIC POWER FOR THRESHING MACHINES.—At Ladenburg, in Germany, on the occasion of a recent meeting of local agriculturists, Messrs. Piette and Krizik lighted up the machine department of the exhibition by means of their lamps, better known under the title of the Pilsen arc lamp, and also drove one of the threshing machines by means of electric power.

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CORRESPONDENCE.

"GLOW" LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to call Mr. Munro's attention to the following definition of "glow," taken from the "Imperial Dictionary":—"To shine with intense heat, or, perhaps, more correctly, to shine with a white heat, to exhibit incandescence. Hence, in a more general sense, to shine with a bright lustre," and to ask him if this is not exactly applicable to a carbon filament in a Swan lamp raised to a state of intense incandescence by a current of electricity?

"Incandescence," as a scientific term applied to a certain effect of heat, must, of course, hold its own, but "glow," as a popular term applied to this new and beautiful light, is prettier, and I venture to think more acceptable. "Glühlampe" is already in general use in Germany.—Yours, &c.,

December 30, 1882. W. H. PREECE.

MISAPPROPRIATIONS BY SCIENTISTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The readers of *The Electrician* must have been impressed for some time back, as I have been, with the frequent misappropriations of scientific inventions, and what would seem to be in harmony with the unhealthy tendency of the age, the too frequent very slightest taste of scruple exhibited in the *tour de main*.

Certainly it is unpleasant enough to have, for example, one's clothes stolen, yet to see them worn before our face is a little too much of a good thing, and under such circumstances we need not be surprised to read the very reasonable remonstrances of the real owners.

I had thought that one of the foremost functions of science was calculated to clear away those one-sided, ungenerous principles that actuate so often a section of the lower, mere trading classes, yet if we encroach in the manner we are at present doing upon the sacred domain of science, with all this elbowing and crushing in order to secure one unjust vantage ground or another, the divinity herself will soon be coerced to change her spiritual for a more worldly character, attracting congenial worshippers devoted more to deified mammon than to the generous nature of science.

It is a positive relief, however, to observe at times a frank acknowledgment of merit in others by eminent scientists whose judgment carries weight with it, against the studied silence, or something worse, of men whose interests lie in an opposite direction.

Your able contributor, Mr. Bosanquet, could doubtless afford to recognise the merits of Dr. Paget Higgs's dynamo, in your issue of the 3rd December, but such recognition might have come with equal grace from others more directly interested in the admission.

In fact, the pursuit of science for itself will always maintain a scrupulous regard for a ready acknowledgment of the principle just named, and in this respect no safer guide could be followed than that of Dr. Faraday, whose scientific researches were too sacred to be sullied by either mere mercenary motives or factitious self-glorification.

Yet, looking back upon the history of only two years, and the extravagant prizes prominently held out for electrical inventions, it is not surprising that so much that is done now may be attributable to that cause, and that so much which is neither just nor equitable should be attempted in order to secure a little of the golden fruit that still hangs so temptingly in this garden of Hesperides; nevertheless, as the crop becomes less heavy and valuable, we may naturally look for a return of more honourable treatment, simply because there would be not sufficient inducement to act otherwise.—Yours, &c.,

W. M.

SELF-REGULATING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The pages of a scientific journal are not, I grant, the proper place for personal controversy; yet I am compelled in self-defence to beg the favour of your insertion of this letter, on the following grounds:—In the first place, in the columns of a scientific journal, Mr. Kapp, under the plea of writing a scientific article, claims on behalf of his friends what had the week before been claimed for myself. I then gave you what I believe to be a true history of the progress of invention in this matter, not advocating, I hope, my own cause pre-eminently. Mr. Kapp now lays claim to the first practical application of an old idea. Will you not agree with me that nearly all the principles involved in the present stage of electric lighting are old—very old? But unless Mr. Kapp can "go back of" mine and others' patents in this country, I fear that his claims will have but small legal right.

I apologise for these personalities, and hope that, as a not infrequent contributor to electric journalism, you will favour me in this single lapse.

There are some remarks made by Mr. Kapp that I would like, in a true spirit of eliciting and perhaps giving information, to be explained explicitly, particularly as Mr. Kapp appears to have given great attention to these matters. He states that, to ensure perfect regulation, a variation of 4 to 6 per cent. of the normal speed of engine must be at command. Although I have not myself found this essential in practice, I should much like to know how it is attained. I have employed some of the best engines, but I cannot with a varying load on the engine maintain such a regularity of speed unless I use an engine nearly twice more powerful than the electrical energy calls for. I am told by a gentleman who has had charge in one of the largest engine factories in this country that I am not alone in my experience.

The effects of the magnetic contra-induction of the armature so very clearly explained by Mr. Kapp have been first described in *La Lumière Electrique* by Marcel Deprez, and perhaps previously to that by A. Breguet. In machines having iron cores to the armature this effect cannot be neglected, but it is much less observable when separated from the mutual induction of the magnet circuits than when these circuits are wound together. At the present stage of electric work, however, I should be surprised to see any maker putting iron into his armature where that armature has to carry over 100 amperes, not so much on account of the loss of efficiency in working as for the reason that the machine must become very cumbrous and costly to make.—Yours, &c.,

PAGET HIGGS.

[We have received other letters on this subject, one of which, from Mr. J. E. Jackson, manager of the Electric Carbon, Storage, &c., Company of Scotland, seems to require from us a little explanation. Our valued correspondents, Dr. Paget Higgs and Mr. Jackson, both admit that their work in connection with compound machines was practically a secret. We in the ordinary course of our labours came across a compound machine made by Messrs. Crompton. Our enquiries failed to elicit the name of any other maker. We waited for some months, hoping some one would give us an opportunity of going into the description of such machines, for it must be recollected that much of our information is for a time confidential. The article of M. Bosanquet gave the opportunity, and we urged Mr. Kapp to describe the compound machine. Probably Mr. Kapp knew as little as we did of Dr. Higgs's work, or we are sure he would have been the last person to have attempted to detract from any man's claims to priority. He could only describe the machine he had studied thoroughly, and give the credit to Messrs. Crompton's firm for constructing such machine. It is a fact that Messrs. Crompton have machines in the market of this type, and that no other maker has. We think Dr. Paget Higgs and Mr. Jackson are to blame for not doing as other well-known men do, taking some members of the technical press into confidence, and putting out of question once and for all claims to priority, by a suitably-worded paragraph which records but does not enter into details. Mr. Jackson states that one of their compound machines has been working in England since last April. This is sufficient for the facts of the case, and now we hope readers will turn from personalities to science.—ED. *E.*]

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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1882.

As usual at the commencement of a new year we take a prospective and a retrospective glance at those incidents most likely to interest our readers. We permit ourselves at this period to break through the ordinary rules of etiquette, and to write about "ourselves." The welfare of the greatest number is supposed to be *the* aim of politicians, and even more so of newspapers. Sometimes the greatest number degenerates into a small numerical quantity, and signifies number *one*. It is but natural it should be so. Yet in our case we are vain enough to think our friends will absolve us from the sin of thinking more of ourselves than of our readers. We have endeavoured to make *The Electrician* not only equal to, but better than any other electrical paper in existence. A little has been done to carry us towards the ideal, much remains to be done. That we have succeeded in some measure is the knowledge that keeps us from slackening our efforts. We are proud to think we have the largest circulation of any old-world electrical paper, we are still more proud of the class of readers who favour us, and we maintain it is the most influential that any class paper has under the sun. Do not our readers think so? There is a small section of our readers that we admire. It is a section whose earnest efforts give a far greater publicity to our notes and to many of our articles than we ever contemplated. These people are more accustomed to wield the paste and scissors than the pen, and we presume it is due to their lack of familiarity with the latter auxiliary that they so seldom mention the title of the paper to which they are indebted for their matter. These are the good, upright, and honest English and American editors whose anxiety for the welfare of the greatest number is so intense as never to permit them to be satisfied that *number one* is in the right position to enable them to turn their attention to number *two*.

We shall not trouble our readers with many details of what we hope to do during the coming year; we may, however, mention that to the list of English contributors we are adding the names of the most prominent among the men of science in America, and shall endeavour not only to detail the results of progress in England, but also in America. The labours of Bell, Brush, Edison, Maxim, &c., have shown us that our cousins are eager and forward in the applications of electricity, and further, their citizens are earnest in the support of new inventions. We cater for the English-speaking race, and not for a particular portion of it.

The most important work of the year has been the passing of the Electric Lighting Act during the last parliamentary Session. The thanks of all interested in the progress of electric lighting are due to Mr. Chamberlain for his perseverance, in the face of difficulties, to get this Act passed. The Act puts a good deal of power into the hands of the Board of Trade, but to no greater extent, probably, than in the case of railway and other public matters. The Board of Trade has framed rules to be followed in the granting of licenses and provisional orders. We have so recently dealt with the draft provisional orders lodged in compliance with the Act and rules, awaiting the decision of Parliament, that we do not propose to deal further with this part of the question. The immediate progress of the electric light depends upon these provisional orders. Isolated installations may be made here and there; but little of a satisfactory nature will be done till it is shown that electricity can be distributed as easily and with greater safety than gas. The public are not unaware of the advantages of a pure light, and shop keepers of almost all kinds will welcome a light that in no way vitiates their goods—whilst sanitarians point out the benefit that must arise from the non-vitiation of the atmosphere. Gas companies, however, need not fear—gas is too valuable a product of manufacture for a variety of purposes to be put aside, and this applies, perhaps, more especially to its use as a heating agent. Twelve months ago it was hoped that reservoirs of electricity had entered upon a practical stage; and so they had to a certain extent. The public, however, had conceived a totally erroneous opinion about storage or secondary batteries—nor has a healthy tone yet been found. Dr. Lodge, Professor Gladstone, and Mr. Tribe have carefully studied the problems found in secondary battery work, and have published their conclusions, the one in the pages of our contemporary, *The Engineer*, the others in papers to *Nature*, and to the British Association. The Sellon-Volckmar secondary battery is said to have been greatly improved during the year, and to be

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now in a state bordering on perfection. The FitzGerald-Crompton battery is, we understand, to be manufactured by Messrs. Crompton and Co. on a practical scale. Several of the companies who have applied for provisional orders are, we are informed, determined to try the storage system on a large scale, and we have no doubt will succeed if they can but grasp the problem aright. We are pretty well convinced that as yet electric light engineers hardly realise what they really want. M. Jablochkoff is said to have a good storage battery, in which sodium plays a prominent part. The arrangement is by no means new—it has been known for a long time—but previous investigators have seen the uselessness of attempting to use materials at once scarce, dangerous, and costly, the first property being really the most disadvantageous.

With regard to lamps, whether incandescent or arc, there is but little new to chronicle. The resistance and the radiating surface of the best known lamps are, perhaps, only tentative, inasmuch as experiments are being constantly made to increase the candle-power obtained per indicated horse-power. We still hold to the opinion that most of the incandescence lamps will sooner or later be made with similar resistance for a given radiating surface, and with universal contacts, so that they can be used like gas nipples, and the lamps will be obtainable from any shop, as are gas fittings. The idea which seems so much in vogue at present of appointing sole agents here and there for certain districts is not good. If electric lighting becomes general, the lamps should be obtainable at any china or glass warehouse, or even at every ironmonger's. Thus far we have spoken of incandescent lamps, and just as improvements are being continually made in them, so also in arc lamps. The improvements are minor improvements in detail, and, so far as we know, there has been no new principle utilised. The Pilsen lamps are coming more into favour; but, otherwise, the lamps of Crompton, Brush, and Brockie are those principally used. Designers are aiming at simplicity of construction, certainty of action, and cheapness of price.

The past year has seen the machines of Gordon and Ferranti completed and exhibited. These, as has already been explained in detail in our columns, are alternate current machines, and do not generally meet with the same amount of favour as continuous current machines. The charging and discharging of electric light cables under the action of alternate current machines has not been considered so fully as the charging and discharging of long telegraph cables. It will, however, have to be considered when large installations are in question, and the time function must then be taken into account. We have heard of large continuous current machines under trial, but, as yet, they are not in a sufficiently advanced state to be made public. A decided step in advance has been made at the works of Messrs. Crompton in the production of the compound machine. It is needless to say more of this machine here as it has been so much referred to lately in our other columns. Whatever credit is due to the manufacture of such machines must undoubtedly be given to Messrs. Crompton, that firm being as yet the only makers for sale of this class of machine. Examples of the Chertemps-Dandeu, and of the Jablockoff machine have been exhibited during the year, also of the Elphinstone-Vincent machine, the latter of which has met with a good deal of favour, and is likely to have a fair future if its performances are at all comparable with the statements we have heard.

Before dealing with the work of individual firms, it will, perhaps, be well to look at the speculation of the year. The following statistics are taken from a list of the principal new companies brought out in the year, prepared by Messrs. Spackman and Sons, of 3, Great Winchester-street Buildings. The complete list was given in *The Times* of January 2:—

Name of Company.	Capital authorised.	Capital offered.	Amount of Shares.	Deposit.	Total Deposit.
	£	£	£ s. d.	£ s. d.	£
Anglo-Austrian Brush Electrical (L.)	500,000	300,000	5 0 0	1 10 0	90,000
Anglo-Pacific Electric Light, Telephone, & Power (L.)	300,000	300,000	5 0 0	1 10 0	90,000
Anglo-Spanish Brush Electric Light and Power (L.)	200,000	100,000	5 0 0	3 0 0	60,000
Australian Electric Light, Power, and Storage (L.)	255,000	155,000	5 0 0	1 10 0	46,500
Birmingham and Warwickshire Brush Electric Light & Power (L)	100,000	100,000	2 0 0	2 0 0	100,000
British Honduras and Cuba Submarine Telegraph (L.)	120,000	60,000	10 0 0	4 10 0	27,000
British Indian Electric Light and Power (L.)	250,000	250,000	5 0 0	1 0 0	50,000
British Insulite (L.)	250,000	125,000	10 0 0	5 0 0	63,000
Brush Electric Light Co. of Ireland (L.)	250,000	130,000	5 0 0	1 10 0	39,000
Brush Electric Light & Power Co. of Scotland (L.)	300,000	150,000	5 0 0	2 0 0	60,000
Brush Midland Electric Light and Power (L.)	250,000	125,000	5 0 0	1 10 0	37,500
Continental Electric Light and Power Corporation (L.)	400,000	200,000	5 0 0	2 10 0	100,000
Devon and Cornwall Electric Light and Power (L.)	100,000	100,000	5 0 0	1 10 0	30,000
Duplex Electric Light, Power, & Storage (L.)	100,000	100,000	1 0 0	0 5 0	25,000
Edison's Indian and Colonial Electric (L.)	250,000	175,000	5 0 0	1 10 0	52,500
Electrical Insulator Manufacturing (L.)	100,000	50,000	1 0 0	0 10 0	25,500
Electrical Share Trust.	500,000	500,000	5 0 0	0 15 0	75,000
Electric Carbon Storage and Apparatus Manufacturing of Scotland (L.)	150,000	75,000	1 0 0	0 10 0	37,500
Electric Fire Alarm and Signals (L.)	100,000	100,000	1 0 0	0 5 0	25,000
Electric Lighting and Maintenance (L.)	2,003,000	1,003,000	10 0 0	2 0 0	200,600
Electric News Telegraph (L.)	150,000	100,000	5 0 0	2 0 0	40,000
Electric Sun Lamp and Power (L.)	200,000	200,000	5 0 0	2 10 0	100,000
European, American, Canadian, & Asiatic Cable (L.)	1,500,000	1,500,000	10 0 0	2 10 0	375,000
Faure Electric Amalgamator (L.)	1,000,000	500,000	10 0 0	2 0 0	180,000
Great Northern Electric Light (L.)	10,000	10,000	1 0 0	0 10 0	5,000
Great Western Electric Light and Power (L.)	250,000	125,000	5 0 0	1 10 0	37,500
Gülcher Electric Light and Power (L.)	300,000	300,000	5 0 0	1 0 0	60,000
Hammond Electric Light and Power Supply (L.)	200,000	125,000	55 0 0	2 10 0	62,500
Henley Electric Light and Power (L.)	100,000	100,000	1 0 0	0 10 0	50,000
Indian and Oriental Electrical Storage and Works (L.)	400,000	200,000	5 0 0	2 0 0	80,000
Jablochkoff Electric Light and Power (L.)	300,000	300,000	5 0 0	1 0 0	60,000
Laing Electric Light and Power (L.)	1,000,000	500,000	10 0 0	2 0 0	100,000
Lancashire Maxim Weston Electric (L.)	100,000	50,000	1 0 0	0 5 0	12,500
London and Globe Telephone and Maintenance (L.)	600,000	270,000	1 0 0	1 0 0	270,000
London and Provincial Electric Lighting and Power Generating (L)	250,000	125,000	5 0 0	3 0 0	75,000
Manchester and District Edison Electric Light (L.)	600,000	300,000	10 0 0	2 0 0	60,000
Markland Electric Lighting Power and Regulator (L.)	200,000	133,900	1 0 0	0 5 0	33,475
Metropolitan Brush Electric Light and Power (L.)	1,000,000	500,000	5 0 0	3 0 0	300,000
Patent Electric Gas Igniting (L.)	100,000	80,000	5 0 0	5 0 0	80,000

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Name of Company.	Capital authorised.	Capital offered.	Amount of Shares.	Deposit.	Total Deposit.
	£	£	£ s. d.	£ s. d.	£
Phœnix Electric Light and Power (L.)	250,000	125,000	1 0 0	0 5 0	31,250
Pilsen Joel and General Electric Light (L.)	200,000	200,000	5 0 0	2 0 0	80,000
Provincial (Brush) Electric Light and Power (L.)	200,000	100,000	5 0 0	1 10 0	30,000
Railway and Electric Appliances (L.)	500,000	250,000	1 0 0	0 7 6	93,750
River Plate Telephone & Electric Light (L.)	100,000	80,000	5 0 0	3 0 0	48,000
Rogers' Electric Light and Power (L.)	510,000	260,000	5 0 0	2 0 0	104,000
Scottish Pilsen Joel and General Electric Light (L.)	200,000	200,000	5 0 0	2 0 0	80,000
Self-generating Electric Light and Power (L.)	300,000	300,000	1 0 0	0 10 0	150,000
South African Brush Electric Light and Power (L.)	100,000	100,000	5 0 0	1 10 0	30,000
South Eastern Brush Electric Light and Power (L.)	100,000	100,000	5 0 0	1 10 0	30,000
Staffordshire and Worcestershire Electric Light and Power (L.)	200,000	200,000	2 0 0	1 0 0	100,000
Standard (Fyfe Main) Electric Lighting and Construction (L.)	500,000	300,000	5 0 0	2 10 0	150,000
Swan United Electric Light (L.)	1,000,000	500,000	5 0 0	2 0 0	200,000
Telephone Company of Ireland (L.)	200,000	200,000	1 0 0	0 10 0	100,000
West Middlesex Electric Lighting (L.)	100,000	50,000	5 0 0	1 0 0	10,000
Yorkshire Brush Electric Light & Power (L)	300,000	200,000	2 0 0	2 0 0	200,000

A number of these companies are already in the hands of the liquidators, and others must follow. An installation here and there of fifty or a hundred lamps will not pay current expenses, and as concessions are of the past, shareholders will ere long demand a searching investigation. Most of these companies have a nominal capital sufficient for one, two, or more large installations. By large, we mean designed to supply a whole town, and our advice would be to select a town or towns, agree with the local authority, and use the capital in a manner similar to that in which capital is used in a town gasworks. The distribution of electricity will follow on similar lines to the distribution of gas. Only rich men and large works manufacture their own gas. Such little gasworks do not pay in a commercial sense, nor will small electric light installations of that kind pay commercially. These works pay well the manufacturers in iron, of gasometers, and so on, and so do small electric light installations pay builders of engines, dynamos, &c. The electric light companies are not formed to build engines or dynamos, &c., but to distribute light; but if they should follow in the footsteps of the "jack of all trades," we forsee a still greater fall. Enough of companies. We are not concerned to find a way out of their difficulties for shareholders; they put shackles around their necks in spite of advice to the contrary, and are now beginning to realise in a wholesome manner that a "burnt child dreads the fire."

The three incandescence lamps of any repute are those of Edison, Maxim, Swan, in alphabetical order. Of these the Edison and the Swan are the most prominent. Large installations of these systems are in contemplation, in progress, or complete.

Edison.—The two largest installations of Edison lamps during the year are those at the Holborn-viaduct, and at the Brünn Theatre. The arrangements at both these places have been more or less completely described in our paper. We may say, however, that a third large Edison machine has recently been sent from America, and will shortly be fixed at Holborn. This is a thousand or twelve-hundred light machine, while those at Brünn are only two hundred and fifty light machines. According to the accounts that reach us from Brünn the lighting is very successful, and has attracted a very large number of interested visitors. It may be granted that the Edison Company has been the first to establish a central station for the distribution of electricity for incandescent lighting to all classes of consumers, and the registration of the consumption by meter. The station at Holborn-viaduct was intended to show the practicability of supplying electricity in a manner analogous to that universally adopted in the case of gas. The company has complied with the necessary forms, and has lodged provisional orders which, if granted, will enable them to set about the work of supplying a far more extended area than that at present covered by them. The experience gained since the starting of the Holborn station, in regard to the fundamental requirements of this class of installation and the practical difficulties to be overcome, has been very valuable, and the company believe that when an adequate area shall have been covered with the requisite conductors, and the various improvements suggested by experience introduced, the central station system of electric lighting will be fairly and successfully able to compete with gas lighting, and will prove remunerative even when competing with gas at the present London prices. This company has made a number of isolated installations for public buildings, factories, ships, &c. We are glad to be able to exonerate this company from any attempt to transact business upon false principles and at unremunerative prices. We believe both the Edison and the Swan companies to be carried on with strict regard to the "bawbees," and every effort is made to obtain a fair return for the capital invested. That there have been a few minutes or hours when darkness held sway over the lamps should not bring adverse criticism; rather we should think the pioneer central station installation in England has been fairly successful, and understand that the experience now gained will greatly lessen the chances of failure. We must confess that we look upon secondary batteries as the source by which to obviate such accidents. A battery that would regulate and store for an hour's supply would be found to be invaluable. Electric light engineers do not, or will not realise this. The Edison Company have reduced the price of their lamps by some 40 per cent. during the year, viz., from 5s. to 3s. Mr. Edison has personally been as active as ever, and has, perhaps, more than ever patronised the Patent Office. It is expected his more recent improvements in machines and lamps will greatly increase their efficiency and economy.

Messrs. R. E. Crompton and Co. have been probably more energetic and more successful than any other firm in introducing the electric light. Not only has the business of the firm greatly increased, necessitating a large extension in their shops at Chelmsford, but they have, in addition to their own work since the formation of the Swan United Company, contracted for and carried out some of the Swan United Company's most important installations; in fact, in speaking of the work of the firm we are compelled to speak of that of the company. A new firm (Messrs. Crompton, Winfield, and Co., of Birmingham) has been formed to manufacture the fittings, &c., necessary for electric light work. Messrs. Crompton and Co. have carried out a large number of installations, among which we may mention the following, where Crompton arc lamps are used:—Messrs. Tate and Sons (Liverpool), Messrs. Vernon and Ewens (Cheltenham), Messrs. Fox and Sons (Staincliffe), town of Dewsbury, Messrs. Littlewood; J. Mackay, Esq.; Cardenosa and Co. (for Spain), Mathewson and Co. (for Egypt), Dahl Brothers (Copenhagen), Johnson and Phillips, Davis (Derby), Kirkham (Russia). Additional lamps have been supplied to Risca Colliery. The Bürgin dynamo manufactured by this company has found many admirers, being used by Mr. Lever (Bowden) the inventor of an arc lamp, the Faure Accumulator Co., the Maxim Weston Co., the Telegraph Construction and Maintenance Co. for exciting the Gordon machine, &c. Installations of the Swan incandescent lamps have been made for W. P. Hope, Esq., Messrs. Johnson and Phillips, P. Jones, Esq. (Chelsea), Messrs. Morewood (Llanelly), and the Steam Yacht "Empress" has been fitted with these lights. Messrs. H. Bennett and Co., of Glasgow, have given orders for six installations of Crompton arc lamps, while Messrs. Norman and Sons (Barrow-in-Furness) have required eight sets of apparatus—

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some for arc some for incandescent lighting. At various times we have mentioned the work being carried out through the agency of Mr. J. H. Greenhill (Belfast), who has had installations at Messrs. Hall and Co. (Cork), Messrs. Guiness, Son, and Co. (Dublin), Messrs. Harland and Woolf (Belfast), Messrs. D. and W. Carmichael, Messrs. Shaw and Sons (Limerick), and for A. R. Walker, Esq. (Newry). The harbour at Fraserburgh has been lighted with arc lights to the order of Mr. Mavor (Glasgow). At the late Munich Exhibition we had the pleasure of meeting Mr. H. Bollinger, to whose order Messrs. Crompton have supplied nine installations for places in Italy and South Germany. At the time, we noticed the lighting of the Birmingham Town Hall for the musical festivals, and besides this the firm of Crompton, Wingfield, and Co., have carried out several installations in and around Birmingham.

The Swan United Company.—As we have stated, many of the installations just referred to consisted of Swan incandescent lamps, and, therefore, besides supplying their own work, the Swan Company manufactured the lamps required for the completion of these orders. The Company has also carried out other works, either through Messrs. Crompton or their own engineers. Thus the former have extended the electric light, twenty arc lamps and three hundred incandescent, through the whole of the General Post Office buildings at Glasgow; also have carried out so far the work at the new Law Courts, where some 450 Swan lamps are now fixed; have extended the work at the Nine Elms Station of the South Western Railway, where 28 arc lamps are now used, as well as the work at Messrs. Laing and White's, of Holborn. The Swan Company has fitted Swan lamps in H.M.S. "Himalaya," in the "Wairarapa," and a sister vessel, belonging to the Steamship Company of New Zealand, in the "Goorkha" and "Rena," belonging to the British India Steam Navigation Co.; in the "Lonsdale," "Cephalonia," and "Pavonia," belonging to the Cunard Steamship Company. The houses of O. E. Coope, Esq. (Berechurch Hall); Captain F. Markham (Penrith), Sir M. W. Ridley (Plessy), J. H. Gartside, Esq. (Manchester), and Mr. Bouron (Edgware-road) have been lighted with these lights, as have the shops, factories, or mills of Messrs. Edmundson (Westminster), Messrs. W. Moore and Sons (Isle of Man), Messrs. Rowntree and Sons (Scarborough), and Messrs. Coxon and Co. (Newcastle-on-Tyne). The light will be found at the Royal Institution. Many of the machines used in these installations are those of Messrs. Siemens. We may state here that Messrs. Siemens seem to have decided to manufacture and supply rather than to undertake lighting, and hence we shall be unable to chronicle lighting work carried out by this eminent firm under the title of that firm.

Engines.—This is not the title of a firm, according to Artemus Ward, but according to our ideas the word may be used as a heading, and we may digress for a moment. With certain exceptions the builders of engines seem to be utterly indifferent to the bringing of their wares to the notice of electric light people. They seem to think that everybody must necessarily know their particular firm, inasmuch as they advertise regularly in certain technical papers. We not long ago had occasion to remark on the ignorance of the eminent writers in the *Saturday Review*, and were surprised shortly after to find many eminent electricians ignorant of the standing of some of the firms of engine builders. The business of engine builders for the next few years in connection with electric light work will be enormous. We are often asked concerning these said builders, and may for once take the occasion to mention a few whose work can be trusted. From inquiries made, we are told that engines built by Marshall and Sons are thoroughly good. Messrs. Crompton have used a number of them, and the men like the engines. The same firm has recently, at Berechurch Hall, tried an engine by Messrs. Davey, Paxman and Co. (of Colchester) who are said to turn out thoroughly good work. Two other engines by this firm are to be used at Nine Elms. When room is an object Hodgson's rotary engine will be found worthy a trial. The engine on the Thames Embankment, by Ransomes Head, and Jefferies, has done good work, and is well spoken of by the Jablochkoff Company. Mr. Hindley, Bourton, Dorset, is giving great attention to engines for electric light work. There are many other well-known makers, but they do not think it necessary to trouble us with any facts concerning their work, which neglect, it may be, does not hurt us. Those engine builders who are alive to the wants of the time during the next few years, and keep themselves thoroughly acquainted with the requirements of electric lighting, designing machines accordingly, doing good, trustworthy work, will reap a rich harvest. Fixed, semi-fixed, portable engines—all are required, and will be, till the forces wasted by nature are harnessed to supply our wants.

The Hammond Company.—During the past year the Hammond Electric Light and Power Supply Company have thrown themselves very thoroughly into the work connected with town lighting, in order to pave the way for obtaining a share of the work of corporations when powers are obtained under the Electric Lighting Act. At Chesterfield they have continued the lighting of the whole town with Brush arc lights and the Lane-Fox incandescent lamps upon the same circuit. While the Brush lights have given great satisfaction, the Lane-Fox lamps have been almost universally condemned; but during the last month a very great improvement has taken place in this lighting, due to the supply of a greatly improved Lane-Fox lamp, and at the present time this installation is in a much more satisfactory state than it was a year ago. A large town installation has also been made by this company at Brighton, where now about 50 Brush arc lights are running from their central station. Town lighting was also done by this company during the exhibitions at Peterboro', Worcester, Tynemouth, and Bradford. Various extensions have been made to the plant previously erected by them. At McClure's, of Stockport, a 16-light apparatus has been exchanged for a 40-light apparatus. At Leslie's, shipbuilders, Hebburn, also, a 16-light apparatus has been exchanged for a 40-light apparatus. R. and W. Hawthorn, Newcastle, have taken 16 more lights; Edwards and Sons, Newcastle, 16-light installation; Palmer's Shipbuilding Company, Jarrow, 16 more lights; Stanner's Close Steel Works, Workington, 16 lights. This company undertook the lighting of the Mersey Tunnel, but the working of the Lane-Fox lamps there was not very successful. A town installation has also been made by them at Cockermouth and Portsmouth. The greatest effort, however, that has been made by this company during the year has been to acquire the Ferranti machine, which they think is by far the best machine in the market. One of these machines has already been erected at the works of Messrs. Copestakes, Hughes, and Crampton, at Nottingham. A machine to run 5,000 lights, and weighing about two tons, is on the point of being finished, and if this works with the efficiency claimed for it the company may have reason to be proud of their acquisition. Applications under the Electric Lighting Act were made by the company for every borough in England, but the company have dropped their applications, hoping to secure orders to become contractors for the work of corporations.

Next week we shall refer again to electric light work; meanwhile, we must not forget our old friend the telegraph. Last year most of our review of telegraphic work was relegated to the second week, but we feel it is deserving of a better fate. We find, however, that even now our space is filled, and part of what we have to say must be left for the future. Then, as land telegraphy had first place last time, we will now put cable work first, briefly glance at the lines laid, leaving details to follow. The giant cable company is the

Eastern Telegraph Company.—This company has during the year extended its connections by means of the Malta-Tripoli cable 204 miles in length, the Trieste-Corfu cable 504 miles in length, and the Alexandria-Port Said cable 153 miles in length, giving a total of 861 miles of cable laid in the year. The company has a total system of over 17,000 miles of cable, besides over 1,500 miles of land lines. Its connections—the Eastern and South African Company and the Black Sea Telegraph Company, have respectively 3,858 miles and 350 miles of cable, the latter having 27 miles of land lines. A continuation of the Eastern Company is the Eastern Extension Company with nearly 10,500 miles of cable and 24 miles of subterranean land lines. The total cable system belonging to these companies comprises, then,

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some 31,704 miles of cable, with 1,590 miles of land lines. The system ramifies to all places of note in the Mediterranean, Egypt, the Red Sea, South East Africa, India, China, Australia, and New Zealand. The oldest cable in the system is the Flinders-Tasmania cable, 180 miles in length, belonging to the Eastern Extension, which was laid in 1869; several long cables of the Eastern and also of the Eastern Extension were laid in 1870, and these cables, to use an old-fashioned phrase, are as good as new.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—The cables above mentioned as being laid by the Eastern Company were manufactured and laid in their bed by the Telegraph Construction and Maintenance Company. Besides these this great cable manufacturing company has manufactured and laid the Grietsill-Valentia cable to connect Germany to America, *viâ* Valentia—a cable over 841 miles in length; the Ceara-Maldonado cable, about 403·5 miles in length; the duplicate Madeira-Lisbon cable, over 568 miles in length; and the Lipari-Salina cable, 7·25 miles for the Italian Government. The manufacture and laying of new cables is, perhaps, among the least onerous work of this company. They are so careful to have everything done in the best possible manner, to neglect no precaution, and every man is so thoroughly imbued with the capability of everything and everybody that success in manufacture and in laying are taken as matters of course. If possible, more pride is taken in the ability of the company and the company's staff to pick up and repair cables than in the primary operations. The task of repairing, especially in deep water, is no child's play; but so well arranged is the work that success is hardly ever doubtful. The spirit evidently exists that Napoleon I. so greatly admired—the spirit which will not let one know when he is beaten. There is no retreat, when work is undertaken it has to be done. The vessels and staff of the company have done some notable repairing work during the year. In the early part of the year the "Kangaroo" repaired the 1874 Atlantic cable near Newfoundland. The North Sea cables, that suffered so severely as to cause a block to continental communication, were repaired. The shore end of the Brazilian Company's St. Vincent-Pernambuco cable was replaced. The Ceara-Maldonado cable, above-mentioned, is a new section of the Western Brazilian Company's system added to the old system, by cutting the cable and adding this new piece. The most notable repair, however, was one by the "Seine," mentioned by us at the time, to the Porthcurnow-Lisbon cable, off the coast of Spain, in a depth of between 2,000 and 3,000 fathoms of water. The "Scotia" accomplished the task of repairing the Brest St. Pierre (1869 Atlantic) about mid ocean. In the course of the repairs, or rather of the sounding, the bottom of the Atlantic was found to be exceedingly rocky and precipitous, varying within a short distance from 990 to 2,300 fathoms. The cable had been frayed, evidently from contact with edges of rocks. A peculiarity during this work was that the old cable was several times brought successfully to the surface, showing that, generally, its strength was unimpaired. The work of repair was successful. Several new lengths of cable were used, and the cable rendered thoroughly efficient. After laying the duplicate Lisbon-Madeira cable, a new shore end was placed at Lisbon. During the laying of the duplicate cable a new shoal was found, not previously entered on the charts. The water shallowed rapidly from 2,400 to 100 fathoms, and the shoal necessitated the laying of the cable a little out of the direct course. The shoal is now marked as the "Seine." It is singular that a similar shoal, known as the "Gettysburg," was found during the laying of the original cable, and caused a divergence in the laying of that cable from the most direct route.

It will be seen that the company has done a good deal of good work during the year.

Next week we shall refer to the cable work of the Silvertown Company.

POST OFFICE TELEGRAPHS.—For the inland telegraph system under the control of Her Majesty's Post Office the year 1882 has been a prosperous one. An increase of £170,000 upon the message receipts is reported, as compared with the preceding year. To meet the augmented traffic which this sum represents, the additional wires which were erected in 1880-1 have had to be supplemented by duplex and quadruplex circuiting. Several additional circuits of the latter kind, and a great number of the former, have been introduced during the past year, adding immensely to the capacity of the wires, and proving beyond all doubt the capabilities of the inland service for dealing with even a still greater increase of business. Indeed, it has been found that the more facilities the department offers, and the greater the efficiency and expedition with which it disposes of the traffic, the greater is the amount of patronage it receives. This is conspicuously the case with news messages, the increase upon which has grown so enormously that the night service between important centres of the kingdom is now almost, if not quite, as heavy as the day service. A vast number of new circuits have necessarily been opened to accommodate the wants both of the Press and the general public; but this, as we have already explained, has been effected for the most part without any great outlay in the shape of extensions. Extensions, however, in respect to another branch of telegraph business have taken place, and this to a considerable extent, namely for the purposes of Telephonic Exchanges. This class of business has been largely developed under the auspices of the Post Office, especially in the Northern Counties—Newcastle, Sunderland, Hartlepool, Middlesbro', Hull, and Bradford being places that may be named as now adequately provided in this respect. The Telephone Exchange system established in Newcastle is especially worthy of mention as perhaps in all respects the most complete and perfect system to be found in any town in the kingdom, or perhaps outside of it either. In the South and West of England, similar exchanges have been established at Newport, Cardiff, and Plymouth, as also in the Midland Counties, notably at Leicester. The system is rapidly growing in public favour, and it will be probably extended to other towns and districts as circumstances may seem to warrant.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are alternative solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. RIMINGTON, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

1, 2, and 3. The same as in the "*Pass*" examination.

4. Draw the "characteristic curve" of a dynamo, and explain what are the various practical uses that can be made of it. Explain in detail the various experiments you would carry out to enable you to draw the characteristic curve of a special machine.

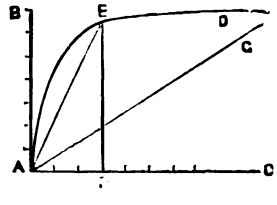

FIG. 1.

Ans. The axis A B represents the E.M.F., the axis A C represents the current. The total resistance required to give any current, A F, when the dynamo is running at the speed for which the curve is constructed, is equal to $\frac{E}{C} = \frac{E F}{A F} = \tan E A F$.

The internal resistance of the dynamo is, of course, constant,

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and can be represented by the tan of an angle G A C. The practical uses of a characteristic curve for a dynamo are that, if we require a given current, we can obtain the resistance in the external circuit necessary to obtain that current, or *vice versâ*.

To find the characteristic curve for a dynamo at any given speed, note the total E.M.F.'s of the machine and the currents corresponding to each total E.M.F. From these co-ordinates a curve is to be constructed.

In practice we should take the E.M.F. at the terminals of the machine and the current flowing at the same time, making, say, twenty observations and varying the external resistance at each observation. If we multiply the E.M.F. at the terminals by the total resistance in circuit and divide by the external resistance, we obtain the total E.M.F. of the machine; now mark off on the axis A B distances to represent the total E.M.F.'s in volts on a convenient scale, and on the axis A C mark off distances corresponding to the current in amperes on the same scale. Draw the ordinates from the corresponding E.M.F.'s and currents, and from the points thus obtained construct a curve.

It is often convenient to draw the divisions representing amperes larger than those representing the E.M.F. in volts. To find the characteristic curve for any increase or decrease in speed, we have only to lengthen or shorten the ordinates representing the E.M.F. in the ratio that the new speed bears to the former, and then to draw a fresh curve through these points. The reason for this is that when the current remains constant the E.M.F. increases or decreases directly with the speed. When a characteristic curve has once been constructed for any dynamo for any one speed, we have all that is necessary for determining (1.) What speed to run the dynamo to obtain a given current through a given resistance. (2.) What current we can obtain through any given resistance at any given speed. (3.) What resistance we shall require to obtain any given current at any given speed.

5. Draw the "characteristic curve" of a magneto-electric machine, and compare the advantages and disadvantages of dynamo and magneto machine.

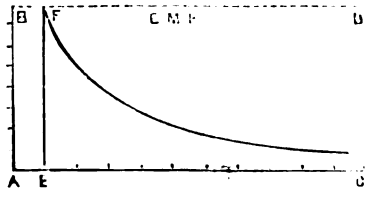

FIG. 2.

Ans. The axis A B represents the current in amperes, the axis A C represents the total resistance in ohms. A E represents the internal resistance, and E C the external. The E.M.F. is practically constant for any fixed speed, and can be represented by the line B D.

Although we may take the E.M.F. of a magneto machine running at a fixed speed as practically constant, it is only approximately so, for the less resistance we have in circuit the greater the current in the armature coils, and this current, acting inductively, tends to neutralise that flowing round the field-magnets, and thus, by diminishing their magnetism, to reduce the E.M.F. of the machine.

The E.M.F. being practically the same is a great advantage when the external resistance is variable, as a greater steadiness and regularity is obtained. In a dynamo, when the external resistance increases, it not only reduces the current, but also the E.M.F., by weakening the field magnets, where in the magneto the current would simply vary inversely as the total resistance. One disadvantage attending the use of the magneto machine is that it requires a separate dynamo to excite it, but where a number are at work of similar dimensions and construction we can employ one dynamo to excite the rest.

6. Given the "characteristic curve" for a dynamo running at 500 revolutions a minute, as well as its resistance, show how you can ascertain at what speed it must run so that a current of 1·3 ampere shall flow through each of 30 incandescent lamps in parallel circuit, the resistance of each lamp for that circuit being 42 ohms?

Ans. Suppose the internal resistance of the dynamo to be 1 ohm.

$$\text{Total external resistance} = \frac{42}{30} = 1{\cdot}4 \text{ ohm.}$$

Current required to work the 30 lamps $= 1{\cdot}3 \times 30 = 39$ amperes.

E.M.F. required to give 39 amperes through a total resistance of 2·4 ohms = 93·6 volts.

Find where the ordinate from the division on diagram corresponding to 39 amperes cuts the curve; this will give the E.M.F. at 500 revolutions, corresponding to a current of 39 amperes, let us say 67 volts.

Then, 67 : 93·6 :: 500 : speed required,

$$\therefore \text{required speed} = \frac{500 \times 93{\cdot}6}{67} = \text{about } 700 \text{ revolutions per minute.}$$

7. How does a "shunt dynamo" differ from a "series dynamo?" Explain fully their relative advantages and disadvantages. Give examples showing the resistances you would employ in each case for the field-magnets and for the armature.

Ans. In a series dynamo the current generated in the revolving armature flows out at one of the brushes round the field-magnets, then through the external circuit, and back again to the other brush. In the shunt dynamo the current generated in the armature divides at the brushes, and flows partly through the external circuit and partly round the field-magnets, the resistance of which is high compared with that of the external circuit. In an ordinary dynamo the E.M.F. is greatest when the machine is short-circuited, in the shunt dynamo when the external circuit is open.

The shunt machine is exceedingly useful where we have a varying external resistance, such as a number of incandescent lamps arranged in parallel circuit, because the greater the external resistance is the more current flows round the field-magnets, thus augmenting the E.M.F. Thus, with a shunt dynamo, it is possible to reduce the number of lamps in parallel circuit down to one; but, to keep the E.M.F. at the terminals constant, we have, of course, to diminish the speed, while with a series dynamo, as we reduce the number of lamps the E.M.F. falls, and to maintain it constant we must increase the speed. Machines are now constructed combining the series and shunt methods of winding the field-magnets, so that the E.M.F. remains constant without altering the speed when the external resistance is increased or diminished within certain limits. In a Siemens shunt dynamo the resistance of the armature is ·4014 Siemens units, and the resistance of the field-magnets is 4·46 Siemens units, while in a Siemens dynamo of corresponding size, the armature being of the same resistance, the field-magnets have a resistance of ·3065 Siemens units.

8. Define an ohm, a volt, an ampere, and a coulomb. A certain magneto-electric machine, with an armature of $\frac{1}{2}$ an ohm resistance, from brush to brush, running at 800 revolutions a minute, produces an electromotive force of 30 volts, what current would this machine send through a wire having 1,000 ohms resistance, if the armature were wound so as to have 5 ohms resistance, and were revolved at 1,300 revolutions a minute?

Ans. An ohm is the practical unit of electrical resistance, or the reciprocal of conductivity, and is equal to 10^9 C.-G.-S. absolute units.

A volt is the practical unit of E.M.F., or the force tending to set electricity in motion. It is the E.M.F. required to produce a current of one ampere through a resistance of one ohm, and is equal to 10^8 C.-G.-S. absolute units.

An ampere is the practical unit of current, and is produced through the resistance of one ohm by a difference of potential of one volt between its ends. It is equal to 10^{-1} C.-G.-S. absolute units.

A coulomb is the unit of quantity. It equals an ampere flowing for one second, and is therefore also 10^{-1} C.-G.-S. absolute units.

The armature having 10 times the resistance would have 10 times the number of convolutions in it if wound with the same sized wire, and at 800 revolutions the E.M.F. would be 200 volts.

$$800 : 1300 :: 30 : x = 487{\cdot}5 \text{ volts.}$$

Total resistance = 1005 ohms.

$$\text{Current} = \frac{487{\cdot}5}{1005} = {\cdot}4857 \text{ ampere.}$$

TRAFFIC RECEIPTS.—The traffic receipts of the Great Northern Telegraph Company in December, 1882, amounted to £17,640. For the period January 1 to December 31, 1882, they were £241,360, and for the corresponding months of 1881 £234,850, against £236,576 during the same period of 1880.

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CORRESPONDENCE.

STATIC ELECTRICITY AND QUANTITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Von Tunzelmann, p. 162, my statement that there is no such thing as a *quantity of static electricity* is not very extraordinary, seeing that, like a good many other people, I do not admit the existence of a quantity of electricity at all, static or dynamic. If electricity is, as I believe, not an entity, but a condition, an action, it cannot be expressed as a quantity. But dynamic electricity is like heat (which also cannot be expressed as a simple *quantity of heats*) in that it has a definite relation to molecules and atoms of matter, and this relation of electricity (as of heat) can therefore be expressed as a quantitative relation or effect.

I wished to draw attention to the fact that such a relation does not exist in what is called static electricity, but which should be called the static actions of electricity. The coulomb is a *quantity* as regards dynamic electricity, but it is a *function* only as to static electricity.

The unit of force is defined to be the force which produces unit of momentum in unit time. But in reply to the question I do deny that there is such a thing as "quantity of force." As with electricity, so with force, there are two ways of regarding it—the natural and the artificial. Mathematicians have, for purposes of calculation, constructed a purely artificial electricity quite different from anything to be found in nature, and the *force* of the mathematician is also an artificial production; very useful, but having no existence. Attraction, pressure, are the true forces, and gravitation is the natural example of them. These cannot be expressed as quantities, but as degrees; to render them expressible as quantities, we have to express them by their effects upon quantities of matter. Now, I am not prepared to admit that measuring an effect as a quantity is really measuring the cause as a quantity. The unit of force is a convenient and necessary measure, but it seems to me that, after all, it is not a measure of force, *i.e.*, not a *quantity of force*, but a measure of energy, the quantity of energy due to a force acting in limited conditions. It is a measure of force, but indirectly.

I do not explain "that by static electricity *I mean* potential energy;" nor can the deduction be drawn that I deny the existence of a quantity of potential energy. It is not worth while arguing a syllogism based upon fictitious resemblances of phrases. I say that what is called static electricity means the existence of conditions in which energy becomes potential, as in a strained spring, I do not see how to express "strained spring condition" as a quantity, but I quite see how to express quantity of energy stored in a strained spring.

I may further say that I do not consider electricity to be "a form of energy," and, therefore, need not argue out the results. I consider it to be a word expressing conditions and phenomena resulting from transfer of energy. I can only say that the point he argues is perfectly familiar to me, as may be seen from the following extract from the second edition of my "Electricity," now passing through the press.

"We not uncommonly hear of the 'conversion of electricity into light, heat, or mechanical energy.' This is an obsolete error, originating in the confusion of the two factors of electricity. Electricity regarded as a quantity calls for two distinct expressions, Q, and Q^2. The first is strictly a quantity, and is that which the old theories considered to be material or analogous to matter, and represented to the mind by the expression, imponderable fluid, but which the new theory considers to be numerical, the action of definite material quantities or molecules. This, which is properly the "electricity," can no more be converted into heat or anything else, than can the water in a steam boiler or hydraulic engine. The second, Q^2 is the electric energy, which is the true cause of electrical phenomena, and which may be converted into heat and work, because it answers exactly to the mechanical energy (also convertible) carried by the water as steam from a boiler, or under pressure in the hydraulic engine."—Yours, &c.,

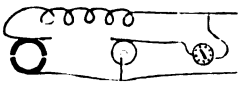
J. T. SPRAGUE.

CURVE OF ELECTROMOTIVE FORCE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the article by Mr. Gisbert Kapp on Crompton's Compound Machine in your issue of Dec. 30, a method of estimating the relative electromotive force in different parts of a Gramme ring while in motion is suggested, which recalls an experiment in which I assisted at the Massachusetts Institute of Technology in Boston, U.S.A., in the spring of 1875. The machine under test was a Farmer dynamo (a simple Siemens armature revolving between the poles of an electro-magnet, the coils of which were in the main circuit), and the curve of E.M.F. at different parts of the revolution was obtained by the following method, due I believe to a fellow student, Mr. Samuel Mixter.

A disc of insulating material (here shown in a different position for the sake of clearness in the diagram) was fixed upon the end of the armature shaft, and carried a band of metal in contact with the shaft, and turned over the edge of the disc so as to make contact at a certain point in each revolution with a spring or brush pressing against the edge of the disc. One terminal of the machine was connected to the base of the machine and so to the shaft, and the spring pressing on the disc was connected through a galvanometer to the other terminal of the machine. Thus, at a certain point in each revolution, the galvanometer became connected between the terminals of the machine, and by making these contacts not too short the effect produced by the rapid succession of currents (the normal speed of the machine was 2,000 revolutions per minute) became very nearly that of a continuous current, the needle not having time to swing back appreciably between successive currents. By shifting the position of the disc on the axis, or of the contact spring, successive observations were obtained of the current at different parts of the revolution.



From the results then obtained with very crude temporary apparatus I have no doubt that excellent determinations of the electromotive force throughout the revolution of the armature could readily be obtained by a similar plan from the better machines of the present day, as in them the successive impulses given to the galvanometer (voltmeter) would be a much nearer approach to a continuous current than in the case I have described. Of course the apparatus must be modified to suit each particular class of machine, as in the form above described it is only suited to a single coil armature. With many coils contacts must be so arranged as to include only a single coil at a time while that coil is passing through a particular part of the field. Thus, with the Gramme ring the apparatus would take a form similar to that mentioned by Mr. Kapp. A ring of insulating material should be mounted so as to surround one end of the commutator, the brushes being sufficiently narrowed to admit it, and this ring should carry two contact springs so adjusted as to rest, at any given position of the armature, upon two successive bars of the commutator In this way as each coil in succession came into the part of the field selected the difference of potential between its extremities would be indicated by a voltmeter connected between the two contact springs. The rapid succession of currents would produce practically the same effect as a continuous one corresponding in E.M.F. to the part of the field selected. By shifting the ring successive observations could be taken throughout the circumference of the field. The modifications necessary for other forms of machine will readily suggest themselves to those familiar with their construction.

I have thought it worth while to bring this matter forward more prominently than was done by Mr. Kapp's casual mention of it, as I am not aware that systematic observations of this kind have ever been made upon any of the machines now in use, although it would seem that if made they could not fail to be most instructive, and to serve a very useful purpose in working out the best forms of pole pieces, position of commutator brushes, and other details entering into the design of a machine, as well as in the comparison of different machines; the importance of a proper distribution of E.M.F.

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throughout the field being evident, as well as the comparative blindness of attempts to secure it without such experimental aid.—Yours, &c., J. B. HENCK, JUN.

31, Queen Victoria-street, E.C.

INDUCTION COIL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Could you inform me what sort of an apparatus I could obtain to regulate the strength of the current of an induction coil which I have finished, the current of which is too strong for that for which I wanted it? And, also, is it possible to ascertain the quantity or resistance of the thick wire in proportion to the fine of an induction coil?—Yours, &c. E. E. M.

Buckhurst Hill, December 30.

CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture I.—The Dynamo in Theory.

By "Dynamo-Electric Machinery," in the most general etymological sense of the term, is meant machinery for converting the energy of mechanical motion into the energy of electric currents, or *vice versâ*. From this wide definition must be excepted machines like the well-known statical induction machine of Holtz, whose action is purely electrostatic. Those machines only are included in the definition whose action is dependent on the principle of electro-magnetic induction, discovered by Faraday, in 1831. It is, however, not quite easy to decide what machines shall be called dynamo-electric machines, because the sense in which the term is used commonly is narrow, and restricted in a manner not quite logical.

The name dynamo-electric machine appears to have been first employed by Dr. Werner Siemens, in his communication of January 17, 1867, to the Berlin Academy, in which he described a machine for generating electric currents by the application of mechanical power, the currents being induced in the coils of a rotating armature by the action of electro-magnets, which were

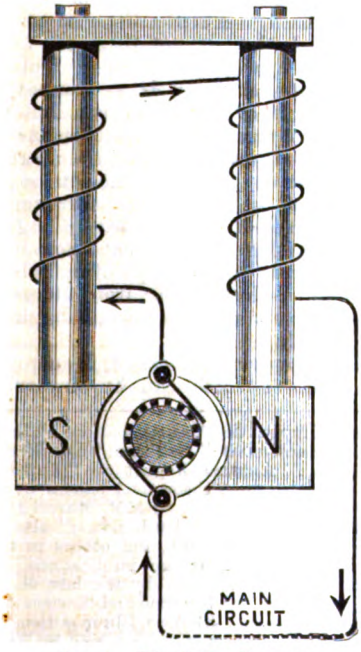

FIG. 1.—The Series Dynamo.

then introduced into electric technology, has not remained thus themselves excited by the currents so generated. The machine was, in fact, a self-exciting dynamo, with the field magnets and armature united "in series" to the external circuit, or what we now call a "series-dynamo," a diagramatic representation of which is given in Fig. 1. But the term dynamo-electric machine, restrained to its narrowest meaning. It was next applied to machines of kindred nature, in which, though self-excited, only a portion of the entire current generated by the rotating armature was applied to excite the field-magnets (see Fig. 2). This principle of working (now known as that of the "shunt-dynamo"), first introduced by Wheatstone, is but a variation of the former arrangement in detail, and no violence is done to the original term to apply it to both cases. In fact, the name was

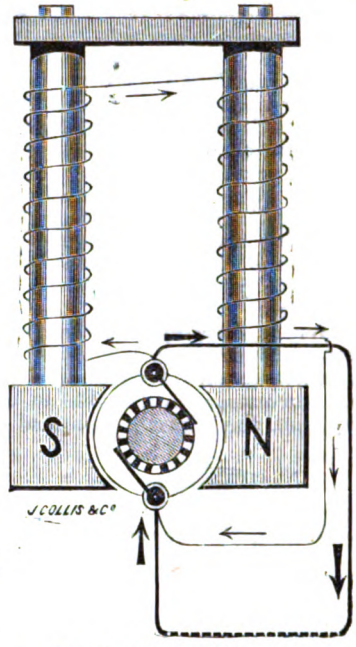

FIG. 2.—The Shunt Dynamo.

welcomed as being convenient in practice for distinguishing such machines from those which were not self-excited—those in which either steel magnets or separately-excited electro-magnets were used to produce the magnetic field.

But since the great development of electric lighting took place, it has been found convenient to use generating machines in certain combinations, in which the self-exciting principle is abandoned. Some systems of electric lights require alternating cur-

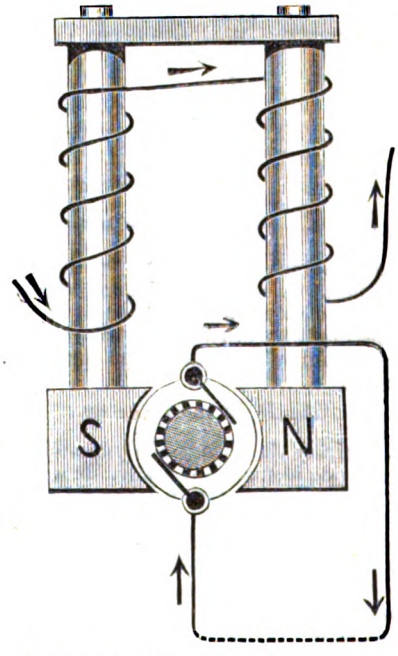

FIG. 3.—The Separately-excited Dynamo.

rents, produced in machines which cannot excite their own magnets with a continuous magnetisation; and there are other systems where continuous currents are employed, in which also practice has shown that the currents are better regulated when the magnets of the dynamos are separately excited by currents derived from an external source. There is, then, a third class of dynamo-electric machine, the "separately-exciting dynamo" (Fig. 3), which was indeed earlier than either of the preceding,

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having been brought out by Wilde in 1866. A dynamo is a dynamo in fact, whether its magnets be excited by the whole of its own current, or by a part of its own current, or by a current from an independent source. The source of the magnetising power is indifferent, provided a magnetic "field" of sufficient intensity be produced wherein the generating coils can be rotated. Now, as it does not matter where the magnetising power comes from, it is clear that we must include amongst possible sources the power of permanent steel magnets. In short, the arbitrary distinction between so-called magneto-electric machines (see Fig. 4) and dynamo-electric machines fails when examined carefully. In all these machines a magnet, whether permanently excited, independently excited, or self-excited, is employed to provide a field of magnetic force. And in all of them dynamical power is employed to do the work of rotating the coils of the armature, in order to generate the electric currents.

The true and comprehensive definition of a dynamo-electric machine is, then, the following:—A dynamo-electric machine is a machine for converting energy in the form of dynamical power into energy in the form of electric currents, by the operation of setting conductors (usually in the form of coils of copper wire) to rotate in a magnetic field.

Inasmuch, however, as every dynamo-electric machine, in the most general sense of the term as now laid down, will work as a motor, and becomes a source of mechanical power when supplied with electric currents, it is possible to discuss dynamo-electric machinery from the opposite points of view in serving

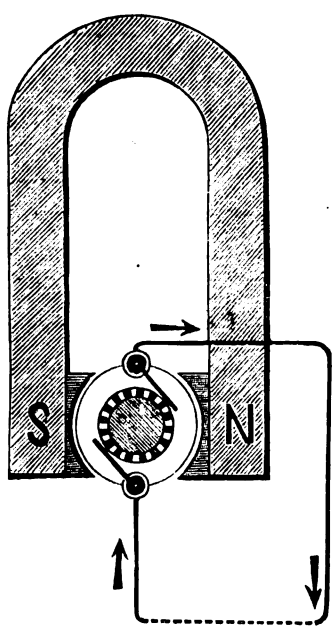

Fig. 4.—The Magneto Dynamo.

the two converse functions, in short, to treat the dynamo on the one hand as a generator, on the other hand as a motor.

It is as a generator only that the action of the dynamo will be considered in the first two of these lectures, reserving considerations respecting its functions as a motor for the third lecture of the present course.

The Dynamo in Theory.

To treat exhaustively the theory of dynamo-electric machines would require not one lecture, but many. It would be necessary, moreover, to enter upon lengthy mathematical and geometrical discussions, which would be out of place in the present course, which is expected to deal with subjects from an industrial, rather than from a purely scientific aspect. The mathematical theory of the dynamo is, indeed, very complex, and takes different forms for its expression in the four classes of machine now included under the one name of "dynamo." For every different variety in each of these classes there is a fresh variety of mathematical symbols. The theory of alternate current machines is entirely different from that of machines which are to furnish continuous and constant currents. Every form of armature and coils requires its own specific treatment in symbols; and the simple consideration of putting iron cores into the coils, when treated mathematically, introduces such complex expressions as to yield no hopes of a satisfactory general solution.

The theory of the dynamo, then, which will be developed in the present lecture, will not be a general mathematical theory. The aim will be to deal with physical and experimental rather than mathematical ideas. A physical theory of the dynamo is not new, though none of any great completeness has yet been given,* most of such explanations being devoted to single machines of some particular type.

It will here be my aim to develop a general physical theory, applicable to all the varied types of dynamo electric machines, and to trace it out into a number of corollaries, bearing upon the construction of such machines. Having recited these consequences, which we shall deduce from theory, it will then remain to see how these consequences are verified and embodied in the various forms assumed by the dynamo in practice.

Physical Theory of Dynamo-Electric Machines.

All dynamos are based upon the discovery made by Faraday in 1831, that electric currents are generated in conductors by moving them in a magnetic field. Faraday's principle may be enunciated as follows:—When a conductor is moved in a field of magnetic force in any way so as to cut the lines of force, there is an electromotive force produced in the conductor, in a direction at right angles to the direction of the motion,† and at right angles also to the direction of the lines of force, and to the right of the lines of force, as viewed from the point from which the motion originates.‡

This induced electromotive force is, as Faraday showed, proportional to the number of lines of magnetic force cut per second, and is, therefore, proportional to the intensity of the magnetic "field," and to the length and velocity of the moving conductor. For steady currents, the flow of electricity in the conductor is, by Ohm's well-known law, directly proportional to this electromotive force, and inversely proportional to the resistance of the conductor. For sudden currents, or currents whose strength is varying rapidly, this is no longer true. And it is one of the most important matters, though one too often overlooked in the construction of dynamo-electric machinery, that the "resistance" of a coil of wire, or of a circuit, is by no means the only obstacle offered to the generation of a momentary current in that coil or circuit; but that, on the contrary, the self-induction exercised by one part of a coil or circuit upon another part or parts of the same, is, in many cases, quite as important a consideration, and in some cases a more important consideration, than the resistance.

To understand clearly Faraday's principle—that is to say, how it is that the act of moving a wire so as to cut magnetic lines of force can generate a current of electricity in that wire, let us inquire what a current of electricity is.

A wire through which a current of electricity is flowing looks no different from any other wire. No man has ever yet seen the electricity running along in a wire, or knows precisely what is happening there. Indeed, it is still a disputed point which way the electricity flows, or whether or not there are two currents flowing simultaneously in opposite directions. Until we know absolutely certainly what electricity is, we cannot expect to know precisely what a current of electricity is. But no electrician is in any doubt as to one most vital matter—namely, that when an electric current flows through a wire, the magnetic forces with which that wire is thereby, for the time, endowed, reside not in the wire at all, but in the space surrounding it. Every one knows that the space or "field" surrounding a magnet is full of magnetic "lines of force," and that these lines run in tufts from the N-pointing pole to the S-pointing pole of the magnet, invisible until revealed by dusting iron filings into the field, whereby their presence is made known, though they are always in reality there (Fig. 5).

Now, every electric current (so-called) is surrounded by a magnetic field, the lines of which can be similarly revealed. To

* See Du Moncel ("Exposé des Applications de l'Electricité," vol. ii.); Niaudet, "Machines Electriques;" Schellen, "Die Magnet-und Dynamo-elektrischen Maschinen;" Antoine Breguet (see "Annales de Chimie et de Physique," 1879). See also some theoretical papers by Clerk Maxwell in "Philosophical Magazine," 1867, and by MM. Marcel Deprez, Cabanellas, de Goarant, and others in the "Comptes Rendus;" also sundry papers by Frölich, Werner Siemens, Hagenbach, and others in the "Elektrotechnische Zeitschrift," and other German publications. Of more general scope is the physical theory advanced by the late M. Antoine Breguet, which deals with dynamos of the Gramme and Siemens type, and of which a detailed summary is given in "Electric Illumination." In an introductory chapter of the same work I have endeavoured to lay the foundation of a more general physical theory. An admirable series of papers on the mathematical theory of dynamo-electric machines, from the pen of a well-known professor of physics, is at present appearing in the columns of *The Electrician*.

† Or, more strictly to the resolved part of the motion in a plane perpendicular to the lines of force.

‡ A more usual rule for remembering the direction of the induced currents is the following adaptation from Ampère's well-known rule:—Supposing a figure swimming in any conductor to turn so as to look along the (positive direction of the) lines of force. Then, if he and the conductor be moved towards his right hand, he will be swimming with the current induced by this motion.

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observe them, a hole is bored through a card or a piece of glass, and the wire which carries the current must be passed up through the hole. When iron filings are dusted into the field they assume the form of concentric circles showing that the lines of force run completely round the wire, and do not stand out in tufts; in fact, every conducting wire is surrounded by a sort of magnetic whirl. A great part of the energy of the so-called electric current in the wire consists in these external magnetic whirls. To set up requires an expenditure of energy, and to maintain them requires also a constant expenditure of energy.

Fig. 5.—Magnetic Field of Bar-magnet.

It is these magnetic whirls which act on magnets, and cause them to set as galvanometer needles do, at right angles to the conducting wire.

Now, Faraday's principle is nothing more nor less than this:—That by moving a wire near a magnet, across a space in which there are magnetic lines, the motion of the wire, as it cuts across those magnetic lines, sets up magnetic whirls round the moving wire, or, in other language, generates a so-called current of electricity in that wire. Poking a magnet-pole into a loop or circuit of wire also necessarily generates a momentary current in the

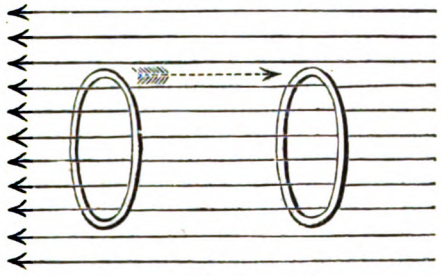

Fig. 6.

Circuit moved without cutting Lines of Force of Uniform Magnetic Field.

wire loop, because it momentarily sets up magnetic whirls. In Faraday's language, this action increases the number of magnetic lines of force intercepted by the circuit.

It is, however, necessary that the moving conductor should, in its motion, so cut the lines of force as to alter the number of lines of force that pass through the circuit of which the moving conductor forms part. If a conducting circuit—a wire ring or single coil, for example—be moved along in a uniform magnetic field, as indicated in Fig. 6, so that only the same lines of force pass through it, no current will be generated. Or, if again, as

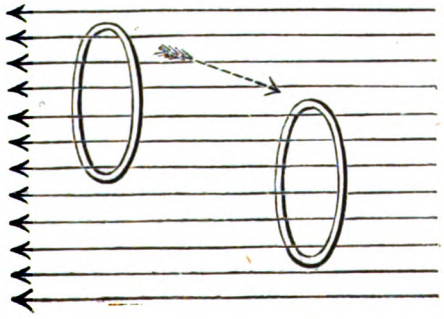

Fig. 7.—Circuit moved without cutting any more Lines of Force.

in Fig. 7, the coil be moved, by a motion of translation, to another part of the uniform part of the uniform field, as many lines of force will be left behind as are gained in advancing from its first to second position, and there will be no current generated in the coil. If the coil be merely rotated on itself round a central axis, like the rim of a fly-wheel, it will not cut any more lines of force than before, and this motion will generate no current. But if, as in figure, the coil be tilted in its motion across the uniform field, or rotated round any axis in its own plane, then the number of lines of force that traverse it will be altered, and currents will be generated. These currents will flow round the ring-coil in the positive* sense (as viewed from the point toward which the lines of force run), if the effect of the movement is to diminish the number of lines of force that cross the coil; they will flow round in the opposite sense if the effect of the movement is to increase the number of intercepted lines of force.

If the field of force be not a uniform one, then the effect of taking the coil, by a simple motion of translation, from a place where the lines of force are dense to a place where they are less dense, as from position 1 to position 2 in Fig. 9 will be to generate currents. Or, if the motion be to a place where the lines of force run in the reverse direction, the effect will be the same, but even more powerful.

We may now summarise the points under consideration, and some of their immediate consequences, in the following manner:—

(1.) A part, at least, of the energy of an electric current exists

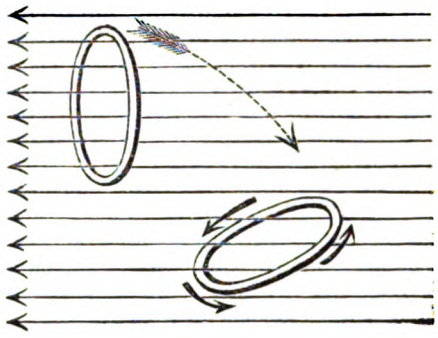

Fig. 8.—Circuit moved so as to alter number of Lines of Force through it.

in the form of magnetic whirls in the space surrounding the conductor.

(2.) Currents can be generated in conductors by setting up magnetic whirls round them.

(3.) We can set up magnetic whirls in conductors by moving magnets near them, or moving them near magnets.

(4.) To set up and maintain such magnetic whirls uses up a continuous expenditure of energy, or, in other words, consumes power.

(5.) To induce currents in a conductor there must be relative motion between conductor and magnet of such a kind as to alter the number of lines of force embraced in the circuit.

(6.) Increase in the number of lines of force embraced by the ciruit produces a current in the opposite sense to decrease.

(7.) Approach induces an electromotive force in the opposite direction to that induced by recession.

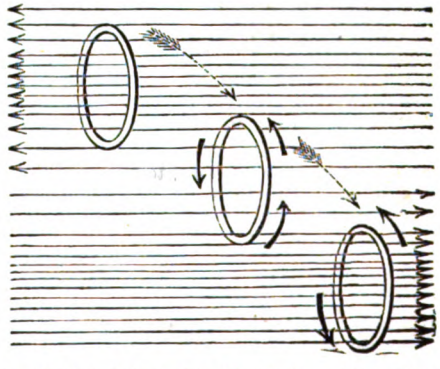

Fig. 9.—Motion of Circuit in Non-uniform Magnetic Field.

(8.) The more powerful the magnet pole or magnetic field the stronger will be the current generated (other things being equal).

(9.) The more rapid the motion the stronger will be the currents.

(10.) The greater the length of the moving conductor thus employed in cutting lines of force (*i.e.*, the longer the bars, or the more numerous the turns of the coil), the stronger will be the currents generated.

(11.) The shorter the length of those parts of the conductor not so employed, the stronger will be the current.

(12.) Approach being a finite process, the method of approach and recession (of a coil towards and from a magnet pole) must necessarily yield currents alternating in direction.

(13.) By using a suitable commutator all the currents, direct

* The positive sense of motion round a circle is that opposite to the sense in which the hands of a clock go round.

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or inverse, produced during recession or approach, can be turned into the same direction in the wire that goes to supply currents to the external circuits, thereby yielding an almost uniform current.

(14.) In a circuit where the flow of currents is steady* it makes no difference what kind of magnets are used to procure the requisite magnetic field, whether permanent steel magnets or electro-magnets, self-excited or otherwise.

(15). Hence the current of the generator may be itself utilised to excite the magnetism of the field-magnets, by being caused, wholly or partially, to flow round the field-magnet coils.

A very large number of dynamo-electric machines have been constructed upon the foregoing principles. The variety is, indeed, so great that classification is not altogether easy. Some have attempted to classify dynamos according to certain constructional points, such as whether the machine did or did not contain iron in its moving parts (which is a mere accident of manufacture, since almost all dynamos will work either with or without iron in their armatures, though not equally well); or whether the currents generated were direct and continuous, or alternating (which is, in many cases, a mere question of arrangement of parts of the commutator or collectors); or what was the form of the rotating armature (which is, again, a matter of choice in construction, rather than of fundamental principle). The classification which I shall adopt is one which I have found more satisfactory and fundamental than any other. I distinguish three genera or main classes of dynamos.

Class I.—Dynamos in which there is rotation of a coil or coils in a uniform† field of force, such rotation being effected (as in the manner indicated in Fig. 12) round an axis in the plane of the coil, or one parallel to such an axis.

EXAMPLES.—Gramme, Siemens (Alteneck), Edison, Lontin, Bürgin, Fein, Schückert, Jürgensen (Thomson's mousemill dynamo) [Brush].

Class II.—Dynamos in which there is translation‡ of coils to different parts of a complex field of varying strength or of opposite sign. Most, but by no means all, of the machines of this class furnish alternate currents.

EXAMPLES.—Pixii, Clarke, Niaudet, Wallace-Farmer, Wilde (alternate), Siemens (alternate), Hopkinson and Muirhead, Thomson (alternate), Gordon (alternate), Siemens-Alteneck (disc dynamo), Edison (disc dynamo), De Meritens.

Class III.—Dynamos having a conductor rotating so as to produce a continuous increase in the number of lines of force cut, by the device of sliding one part of the conductor on or round the magnet or on some other part of the circuit.

EXAMPLES.—Faraday's Disc machine, Siemens's ("Unipolar" Dynamo), Voice's Dynamo.

One machine, and one only, am I aware of, which does not fall exactly within any of these classes,§ and that is the extraordinary tentative dynamo of Edison, in which the coils are waved to and fro at the ends of a gigantic tuning fork, instead of being rotated on a spindle.

Suppose, then, it were determined to construct a dynamo upon any one of these plans—say the first—a very slight aquaintance with Faraday's principle and its corollaries would suggest that, to obtain powerful electric currents, the machine must be constructed upon the following guiding lines:—

(*a.*) The field-magnets should be as strong as possible, and their poles as near together as possible.

(*b.*) The armature should have the greatest possible length of wire upon its coils.

(*c.*) The wire of the armature coils should be as thick as possible, so as to offer little resistance.

(*d.*) A very powerful steam engine should be used to turn the armature, because,

(*e.*) The speed of rotation should be as great as possible.

Unfortunately, it is impossible to realise all these conditions at once, as they are incompatible with one another; and, moreover, there are a great many additional conditions to be observed in the construction of a successful dynamo. We will deal with the various matters in order, beginning with the speed of the machine.

Relation of Speed to Power.

Theory shows that, if the intensity of the magnetic field be constant, the electromotive force should be proportional to the speed of the machine. Numerous experiments, by many different workers, have shown that this is true, within certain limits, for those machines in which the field magnets are independent of the main circuit, that is to say, for magneto and separately-excited dynamos. It is not, however, quite exact, unless the resistance of the circuit be increased proportionately to the speed, because the current in the coils itself reacts on the magnetic field, and alters the distribution of the lines of force. The consequence of this reaction is that, firstly, the position of the "diameter of commutation" is altered; and, secondly, the effective number of lines of force is reduced. So that, with a constant resistance in circuit, the electromotive force, and, therefore, the current are slightly less at high speeds than the proportion of the velocities would lead one to expect. Since the product of current into electromotive force gives a number proportional to the electric work of the machine, it follows that, for "independently excited" machines, the electric work done in given time is nearly proportional to the square of the speeds, and the work drawn from the steam engine will be similarly proportional to the square of the speed.

In self-exciting machines, whether "series" or "shunt" in their arrangements, a wholly different law obtains. If the iron of the field-magnets be not magnetised near to saturation, then, since the increase of current consequent on increase of speed produces a nearly proportional increase in the strength of the magnetic field, this increase will react on the electromotive force, and cause it to be proportional more nearly to the square of the velocity, which again will cause the current to increase in like proportion. But since the magnetisation of the iron is, even when far from saturation point, not exactly proportional to the magnetising force, but something less, it is in practice found that the electric work of the machine is not proportional to the fourth power of the speed, is not even proportional to the third power of the speed, but to something slightly less than the latter.

As mechanical considerations forbid too high a velocity in the moving parts, it is clear that, if there be a limiting speed at which it is safe to run any given armature, the greatest amount of work will be done at that speed by using the most powerful magnets possible, namely, electro-magnets rather than magnets of steel.

Marcel Deprez has shown* that it is convenient to study the action of dynamos, by constructing a curve which he calls a "characteristic," showing, for any given speed, the relation between electromotive force and strength of current generated in a circuit of given resistance. Amongst other conclusions, M. Deprez has found that for every dynamo there is a certain speed, which we may call the "critical speed," at which, no matter what the current is which circulates in the coils of the field magnets, the electromotive force is proportional to the strength of that current; and he bases upon the discovery of this critical speed two methods of utmost importance in practice, for obtaining, automatically, either a constant electromotive force or a constant current at will, in a circuit in which the resistances are varied to any degree.

In all these combinations, however, everything depends upon the condition that the driving speed shall be uniform. For all the best kind of electric work, a gas engine is wholly out of the question as a source of power, because of its extreme inequalities in speed. Even with the best steam engines, a specially sensitive valve is required; and, probably, such valves will, in the future, be operated electrically by self-acting electro-magnet gearing. In any case, where the driving is at all liable to be uneven, the obvious and simple precaution should be taken of placing a heavy fly wheel on the axis of the dynamo. It is, indeed, singular that this is not more generally done.

(TO BE CONTINUED.)

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* For currents that are not steady, there are other considerations to be taken into account, as will be shown hereafter.

† Or approximately uniform. A Gramme ring, or a Siemens drum armature, will work in a by no means uniform field, but is adapted to work in a field in which the lines of force run uniformly from one side to the other. But in such a field, a multipolar armature of many coils, such as that of Wilde, or such as is used in the Gramme alternate current, or in the Siemens alternate current machine, is useless and out of place. Indeed, the classification almost amounts to saying that in machines of Class I. there is one field of force, while in machines of Class II. there are many fields of force, or the whole field of force is complex.

‡ The motion by which the individual coils are carried round on such armatures as those of Niaudet, Wallace-Farmer, Siemens (alternate), &c., is, of course, not a pure translation. It may be regarded, however, as a combination of a motion of translation of the coil round the circumference of a circle, with a rotation of the coil round its own axis, which, as we have seen above, has *no* electrical effect. It is, of course, the translation of the coil to different parts of the field which is the effective motion.

§ There are a few dynamos, including the Elphinstone-Vincent, and the four-pole Gülcher, which, though really belonging to the first class, are not named above, because they are, in reality, compound machines. The Gülcher, with its double field magnets and four collecting-brushes, is really a double machine, though it has but one rotating ring. The same is the case with an octagonal-pattern Gramme, which has four brushes. The Elphinstone-Vincent machine, a remarkable one in many respects, is a triple machine, having six brushes, and may, indeed, be used as three machines, to feed three separate circuits.

* *Comptes Rendus*, 1881, and elsewhere. For an excellent summary of the work of M. Deprez, see *La Lumière Electrique*, February 18, 1882.

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DETECTION OF METALLIC MASSES IN THE HUMAN BODY.*

BY ALEXANDER GRAHAM BELL.

(CONTINUED FROM PAGE 167.)

Mr. Marean, of Washington, kindly lent me a number of condensers used by the Western Union Telegraph Company, and we found, upon connecting them with the coils E F, as shown in Fig. 17, and, holding a leaden bullet near the coils, that each condenser reinforced a high upper-partial of different pitch. We arranged the condensers so that they could be successively introduced into the circuit with great rapidity. The effect was very curious, and sounded somewhat like a Scotch air played upon the bagpipes. The low hum of the fundamental could be heard continuously like the drone of the bagpipe, while the higher tone changed its pitch with each change of condenser.

The pitch of the high tone reinforced seemed to depend upon the electrostatic capacity of the condenser employed, but the exact relation between the two has not been ascertained. In Experiments 5, 6, 7, 8, and the subsequent experiments described above, the battery employed consisted of six pairs of carbon and zinc plates of large area placed in a solution of bichromate of potash containing sulphuric acid.

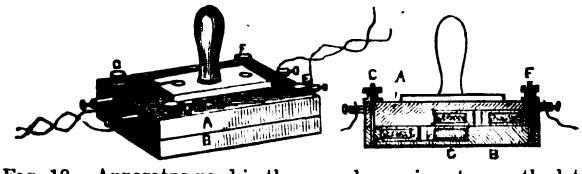

FIG. 18.—Apparatus used in the second experiment upon the late President Garfield, August 1, 1881.

The effects noted above were not produced satisfactorily when the battery was much run down, nor were they obtained with a Leclanché battery which had been set up for some time, but which appeared to be in good condition.

It is evidently necessary in order to produce this characteristic high tone to use a battery possessing considerable electromotive force and slight internal resistance.

Our experiments had reached this stage when, on Saturday, the 30th of July, 1881, I was requested to make another trial upon the person of the President at the evening dressing of the wound.

At this time, however, we had no exploring instruments completed excepting one or or two like that shown in Fig. 11; for it will be understood that the promising results noted above had been obtained from coils that were simply placed upon a table and adjusted by hand.

We immediately proceeded to the executive mansion with the apparatus shown in Fig. 13, prepared to make a trial, if it was deemed advisable; but upon learning of the results of our later experiments the surgeons resolved to postpone any further trial until we could arrange the coils (Fig. 17) in a portable form.

By forced exertions the coils were arranged that same night in a wooden case, as shown in Fig. 18. This case consisted essentially of two oblong

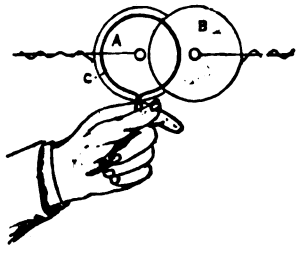

FIG. 19.

blocks A B. A shallow circular recess was turned out in each block for the reception of one of the coils, and the two blocks were held together by four pins of ebonite, C, D, E, F, which passed up through slots in the upper block and were secured by ebonite thumb-screws.

When the instrument was completed I found to my great distress that a balance could not be obtained by any adjustment of the apparatus. There was a position of minimum sound, and the telephone responded to a bullet presented to the central part G of the instrument; but the hearing distance did not exceed 3 or 4 cm., whereas we had obtained with the same coils before the construction of the wooden case a perfact balance and a hearing distance of 13 cm.

After numerous unsuccessful experiments had been made to ascertain the cause of the difficulty it occurred to me that if two adjoining convolutions in one of the coils made contact at any point a circuit of low resistance would be formed (a single ring of wire, in fact) in which the induced currents might circulate without reaching the telephone connected with the apparatus. I had previously measured the resistance of the coils without discovering any defect, but when I considered the large number of convolutions in each coil it seemed possible that a defect of this kind might exist which could not be discovered by a Wheatstone bridge except by very delicate and accurate observations. To test whether a short-circuited convolution would produce effects analogous to those observed, a piece of copper wire was bent into an annular form, and the ends connected together. On bringing this metallic ring near a pair of coils (A, B, Fig. 19) properly adjusted to silence the balance was loudly disturbed. The copper ring (C) was held as shown in Fig. 19, and the balance could not then be restored by any adjustment of the coils. A position of minimum sound was all that could be obtained, and the hearing distance was enormously reduced. This was *prima facie* evidence of the nature of the defect.

The coils (Fig. 18) were then removed from their case, but a cursory examination revealed no defect. Upon trial, however (being arranged, as formerly, in Fig. 17), a balance could not be obtained, and the hearing distance was only about four cm. The defect was thus definitely located in the coils themselves.

Upon close examination it was noticed that the outside convolutions of the primary coil were slightly frayed at one part, but it appeared hardly possible that so great a defect could be due to so apparently slight a cause. However, to test the matter, I removed the outside layer of wires and then tested the coils again.

Result: The defect had vanished—a perfect balance was obtained, and the hearing distance was again 13 cm.*

The coils were then replaced in their case and the completed instrument tested. The lower wooden block B (Fig. 18) was adjusted by hand as nearly as possible to the position of silence, and then the thumb-screws C, D, E, F were tightened.

The balance now obtained was not quite perfect, but by striking the lower block B a few smart blows with a wooden mallet we were able to reduce the arrangement to complete silence.

The instrument was then in such a sensitive condition that it could scarcely be moved without affecting the balance. Upon gently swaying it backwards and forwards a pulsation of sound was heard at every swing.

When the motion was carefully made, so that it was always in the same plane, no pulsations were observed. They only occurred when the inclination of the coils was changed.

This defect was found to be due to the bulging of the thin portion G of the wooden case (Fig. 18) under the weight of the enclosed coil, and the simple pressure of a finger on this portion of the case disturbed the balance. The movement of the lower coil when the instrument was swayed about must have been inconceivably small, but on account of the extreme sensitiveness of the arrangement it produced a perceptible effect upon the balauce.

The pulsating sound did not seem to interfere with the detection of a bullet held in the clenched hand, nor did it seem to affect the hearing distance. I, therefore, despatched a messenger to the Executive Mansion (Sunday morning, July 31st), with a note for Dr. Bliss, to let him know that the instrument was in a condition to be used, should any necessity arise for an immediate experimect. At the same time I informed him that the apparatus in its present form was very crudely constructed, and that I hoped to improve it very greatly in the course of a few days. On Sunday afternoon (July 31st) we sent to the Soldiers' Home for John M'Gill, upon whom we had experimented the previous day without results (using the apparatus shown in Fig. 11).

Upon trying the new instrument (Fig. 18) we had no difficulty in finding a sonorous spot in his back, at the place where the bullet was always supposed to be.

This result was at once communicated to Dr. Bliss, and in reply we were requested to make the experiment upon the person of the President next morning.

On Monday morning (August 1st, 1881) we accordingly removed our apparatus to the Executive Mansion.

The late President Garfield.

During the former experiment (July 26) a sudden sonorous effect had been observed upon passing a point near the spot where the surgeons suspected the bullet to be lodged, but I had been unable to verify this by a second observation, although the exploring instrment (A B, Fig. 13) was repeatedly passed over the same place. The sound had been so loud and well marked that I believed at the time it must have been caused by a sudden irregularity in the vibration of the reed of the rheotome used to interrupt the primary circuit, for the arrangement (as explained above), was not perfectly balanced, and any irregularity of this kind would, under these circumstances, have affected the telephone. At the same time the coincidence was remarkable that the exploring instrument should have been at that very time so near the suspected seat of the ball, and this led to the thought that perhaps after all the bullet had been the cause of the sound. I felt confident that the new instrument (Fig. 18) would at once decide the question, for the extreme hearing distance of the former apparatus (Fig. 13) was only 6cm., and the apparatus shown in Fig. 18 was so superior in this respect that if the sound had really been due to the bullet we should obtain with the new instrument distinct and well-marked effects. When the new explorer (Fig. 18) was passed over the suspected

* A Paper read before the American Association for the Advancement of Science at the Montreal Meeting, August, 1882.

* These experiments have revealed the cause of the extreme difficulty always experienced in obtaining a perfect balance with coils of fine wire. I have recently used an induction balance to test the condition of the helices that were employed in these researches, and have discovered that in a large percentage of cases the insulation was defective. It is possible that some of the results described in this paper (especially of the earlier experiments) may have been vitiated by errors due to defects in the coils that were not suspected at the time. A defect of insulation that is quite immaterial for ordinary purposes may be absolutely fatal to the success of an induction balance. Indeed, so much care is required in this respect that it is extremely difficult to obtain coils that are perfectly suitable for an apparatus intended to search out a bullet imbedded in the body. I now make it a rule to test every helix used in induction balance experiments by bringing it up to a system of balanced coils like that shown in Fig. 17.

1. If the helix is perfect the balance is not disturbed until the terminals of the coil are connected.

2. If there is a break in any of the convolutions the balance is not disturbed, even when the terminals are connected.

3. If a convolution is short-circuited the balance is disturbed, even though the terminals are not connected, and the sound produced is the fundamental of the rheotome employed to interrupt the primary circuit.

4. If the insulation is defective the balance is disturbed, although the terminals are not connected, and a peculiar spluttering effect is noticed like that produced by a series of sparks.

I propose to apply this method practically as a means of testing the condition of the helices used in the construction of induction coils and those employed in the manufacture of telephones.

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spot nothing was heard excepting a slight pulsating sound as the instrument was moved to and fro. This was evidence to me that the former sound had been of accidental origin, whether the bullet was there or not. With the view of eliminating any error of observation caused by pulsations due simply to the movement of the instrument, I lifted the latter (without changing the inclination of the coils) to a height of about 50 centimetres above the body of the President, and moved it to and fro in as nearly as possible the same way I had done at the lower elevation.

I presumed that if the pulsations heard were due simply to the movement of the instrument, they should occur with equal strength at the two elevations; but if any portion of the sonorous effect was due to the influence of the bullet, the pulsations at the two elevations would be different in intensity. I was struck by the fact that, although the sonorous pulsations were very feeble, they were sensibly louder when the instrument was close to the surface of the body than when it was raised. Continuing the exploration, I found a considerable area over which similar effects were noticed, but upon carrying the instrument towards the back of the President, the difference between the pulsations produced at the two elevations grew less and less, and finally could not be distinguished.

The difference in the loudness of the sound at the two elevations was so slight that it probably would not have been noticed by an ear unaccustomed to listen to feeble effects, and I feared that the general expectation that the bullet would be found in that part of the body might have led me to imagine a difference that did not exist. For the purpose of eliminating as far as possible any personal error, I requested Mr. Sumner Tainter (who was the only other person present whose ear had been sufficiently trained to be reliable in such an emergency) to repeat the experiments and let me know the result. Upon our return to my laboratory we compared notes, and I found that his observation tallied with mine. He declared he could not obtain a distinctly localised effect, but stated that he had observed a reinforcement of the pulsation over an area of at least two inches in the neighbourhood of the spot to which his attention had primarily been directed, and that he was convinced that the bullet was within that area.

It appeared reasonably certain that the area of feeble sound was due to some external cause, and was not simply an effect of expectancy. In the absence of any other apparent cause for the phenomenon I was forced to agree in the conclusion that it was due to the presence of the bullet, and I so stated in my report to the surgeons. I was by no means satisfied, however, with the results obtained, for no such effects had been observed before in our experiments with bullets. I tried to reproduce the effects by moving the instrument (Fig. 18) at different distances over a bullet, but in every case where an effect was produced the sound was quite sharply localised. I thought that perhaps the body of the patient might have affected the result, and so experimented upon a bullet buried in a piece of meat, but no difference of effect was noted. This led me to fear that the extensive area of feeble sound might have been due to some extensive area of metal that was unsuspected at the time, and I proceeded to the Executive Mansion next morning (August 2) to ascertain from the surgeons whether they were perfectly sure that all metal had been removed from the neighbourhood of the bed. It was then recollected that underneath the horsehair mattress on which the President lay was another mattress composed of steel wires.

Upon obtaining a duplicate, the mattress was found to consist of a sort of net of woven steel wires, with large meshes. The extent of the sonorous area having been so small, as compared with the area of the bed, it seemed reasonable to conclude that the steel mattress had produced no detrimental effect.* I was unable to continue experiments with the steel mattress, as just at this time I was obliged to leave Washington on account of illness in my family. Although I was unable for a long time afterwards to carry on personally induction balance experiments, the investigations were ably continued under my direction by Mr. Thomas Gleason, in the establishment of Mr. Charles Williams, jun., in Boston.

(TO BE CONTINUED.)

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

Report of the directors, to be presented at the tenth ordinary general meeting of the Company on January 11, 1883:—The directors submit their report and the accounts of the Company for the year ended September 30, 1882. During the year communication has been opened with Maldonado and Ceara, and it has been found necessary, owing to the great length of the Company's system (3,700 miles) and the consequent expense and delay in making repairs, to contract for the purchase of a second steamer. The total earnings amount to £115,169 16s. 11d., a decrease of £1,221 8s. 7d. compared with last year. In addition to which £936 8s. 5d. has been recovered from the underwriters in *re* the Quintero case, and £2,938 18s. 1d. for interest on deposits, the total gross receipts being £119,095 3s. 5d., against £118,882 7s. 2d. The working expenses for the year amount to £61,919 3s. 8d., as against £70,461 10s. 3d, a decrease of £8,542 6s. 7d. The maintenance for the year amounts to £31,728 10s. 2d., as against £41,807 9s. 3d. After paying the debenture interest the balance remaining to the credit of the net revenue account is £30,175 19s. 9d., against £16,559 1s. 6d. for 1880 1881. Since the last report a further sum of £6,693 8s. 6d. has been recovered on account of the compromise of the suit previously mentioned, finally closing this litigation. The total amount recovered the directors have, under the advice of counsel, placed to the credit of renewal account. The directors are of opinion that the time has now arrived to deal with the readjustment of the capital account of the Company, and have submitted a case to Sir Henry James, Her Majesty's Attorney-General, and Mr. Horace Davey, Q.C., who have advised that the capital lost should be written off, and that until this has been done any surplus revenue of the Company cannot properly be appropriated for dividend purposes. In their last report the directors stated that it was no longer advisable to retain the Central American Company's Securities upon the books of this Company as an asset. The shareholders are aware that the matter has been the subject of consideration for some years past, and that the auditor has repeatedly suggested that the amounts represented by these securities should be written off; this suggestion the directors recommend for the adoption of the shareholders. In addition to the losses caused by the Central Company, it is thought expedient to reduce the capital account by an amount which it has been found necessary to expend in order to place the cables in a more efficient condition, and by certain claims for depreciation, ship, instruments, &c., which will increase the amount to be written off to £5 per share, or £349,550, which is thus made up:—Central Company, £284,521 9s. 4d.; outlay for renewal, depreciation of ship, instruments, &c., £65,028 10s. 8d.; total, £349,550. It has been suggested by a large and influential body of the proprietors that the shareholders should have the option of dividing their shares into two classes of equal nominal value:—1. Preferred Ordinary, carrying (as against the Deferred Ordinary shares) a preferential dividend of 5 per cent., cumulative. 2. Deferred Ordinary, which shall be entitled to the surplus earnings declared applicable for dividend after the dividend payable on the Preferred Ordinary shares. The annexed special resolutions for the reduction of the capital, and otherwise, will be submitted to the shareholders at the extraordinary meeting to be held after the ordinary annual meeting. Including the amount brought forward from last year, the balance to the credit of the net revenue account is £48,250 11s. 11d., out of which amount the Board propose to place £12,000 to the renewal fund, and when the necessary legal formalities for reduction of the capital have been complied with, will recommend the division among the shareholders of 3 per cent. on the reduced capital, or £31,459 10s., free of income-tax, carrying forward the balance to next account. This will give, if the proposed division of shares is carried out, a dividend of £5 per cent. to the Preferred Ordinary, and £1 per cent. to the Deferred Ordinary shares. The retiring directors are Messrs. Wood and Andrews, who offer themselves for re-election. The auditor, Mr. Weise, retires, and is eligible for re-election.

* The death of President Garfield, and the subsequent *post-mortem* examination, however, proved that the bullet was at too great a distance from the surface to have affected our apparatus.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Jan. 3.		Business Done Week Ending Jan. 3. Highest.		Lowest.	
Anglo-American	48½,	49½	.....	49	.....	48⅝
Do. Preferred	£0,	81	.....	80½	.....	80½
Do. Deferred	17½,	18½	.....	18⅜	.....	18⅛
Brazil Submarine	11½,	12	.....	12	.....	12
Cuba	9½,	10½	.....	—	.....	—
Do. Preference	17,	18	.....	—	.....	—
Direct Spanish	6½,	7	.....	—	.....	—
Do. Preference	16,	17	.....	—	.....	—
Direct United States Cable	11⅛,	12	.....	11¼	.....	11 13-16
Eastern Telegraph	11,	11½	.....	11 3-16	.....	11
Do. 6 per Cent. Preference	13¾,	13⅞	.....	—	.....	—
Do. 5 per Cent. Debentures, 1899	101,	107	.....	—	.....	—
Eastern Extension	11⅞,	12⅛	.....	12⅛	.....	11⅞
German Union	10½,	10⅝	.....	—	.....	—
Globe Telegraph and Trust Company.	6¼,	6⅜	.....	6 9-16	.....	6⅜
Do. Preference	12,	13	.....	12 15-16	.....	12⅝
Great Northern	12¼,	12⅜	.....	12⅜	.....	12⅜
Indo-European	31,	32	.....	31	.....	31
Mediterranean Extension	1½,	2	.....	—	.....	—
Do. Preference	6,	8	.....	—	.....	—
Reuter's	12½,	12⅝	.....	12	.....	12
Submarine	250,	255	.....	—	.....	—
West India and Panama	1½,	1¾	.....	1⅞	.....	1⅝
Do. 1st Preference	7,	7½	.....	—	.....	—
Western Brazilian	8,	8½	.....	8½	.....	7⅞
West. Union 7 per Cent. 1st Mortgage	122,	126	.....	—	.....	—
Do. 6 per Cent. Sterling Bonds	102,	105	.....	—	.....	—

TELEPHONES.

Consol. Telephone and Maintenance	½,	¾	.....	13-16	.....	⅝
Oriental	½,	¾	.....	13-16	.....	⅝
United Telephone	10½,	11½	.....	11 5-16	.....	11 5-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	7,	7½	.....	7⅛	.....	6 1-16
Do. (fully paid)	11,	14	.....	13½	.....	13½
Gülcher (£1 10s. paid)	—,	—	.....	—	.....	—
Hammond Light	2⅞,	3½	.....	3⅛	.....	2⅞
Eastern Electric (£4 p. d.)	1½,	1⅞	.....	1⅞	.....	1⅞
Pilsen, Joel, and General Electric	1,	1½	.....	1 13-16	.....	1 13-16
Swan	1⅞,	2	.....	1⅞	.....	1½
Maxim-Weston	⅜,	⅝	.....	7-16	.....	5-16

TRAFFIC RECEIPTS FOR DECEMBER, 1882.

Companies.	Dec., 1882.	Dec., 1881.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,741	59	—
Great Northern Telegraph Company	17,640	—	—	—

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SLIP

DIVIDEND.—The directors of the German Union Telegraph Company announce an interim dividend of 5s. 9d. per share.

RAILWAY AND ELECTRIC APPLIANCES COMPANY.—A special meeting of this company has been called for the 24th inst.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 5th inst. amounted to £3,356.

THE INVENTORS' INSTITUTE.—On Thursday last Mr. T. Morgan was to read a paper on Recent Electrical Patents before the Inventors' Institute.

RESIGNATION.—Mr. A. L. Lineff has resigned the office of electrical engineer to the London and Provincial Electric Lighting and Power Generating Company.

INDIAN TELEGRAPH DEPARTMENT.—A Reuter's telegram from Calcutta, dated Jan. 5, says that the Indian Postal and Telegraph Departments are not to be amalgamated.

MESSRS. FERRANTI, THOMSON, AND INCE.—We are informed that Sir Charles Laurence Young, Bart., has joined the board of directors of Ferranti, Thomson, and Ince (Limited).

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of December, 1882, amounted to £49,610, and to £49,844 in the corresponding period of 1881.

ELECTRIC LIGHTING AT THE MINT.—The Royal Mint, which has just been entirely reconstructed, will be lighted by electric light, and telephones will be largely used throughout the building.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended Dec. 31 are £2,080, as compared with £2,405 in the corresponding period of 1881.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of December, 1882, amounted to £31,617, and to £31,319 for the corresponding period of 1881, being an increase of £298.

LONDON PLATINO TELEGRAPH COMPANY.—The revenue of this company for the month of October is estimated at £2,112 (Western Brazilian portion £1,546, land lines £566), as against £1,856 for the corresponding period of 1881.

ELECTRIC LIGHTING AT LIVERPOOL DOCKS.—The Mersey Docks and Harbour Board have made an alteration in one of their bye-laws, whereby work will be allowed to be carried on on board ships in graving docks by the use of electric lights or gas.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.—At the meeting of the society, to be held on Thursday. the 18th inst., at 8 p.m., Mr. Willoughby Smith will deliver his inaugural address, as president, for the ensuing year.

ELECTRICAL EXHIBITION AT VIENNA.—We have received official notice that this exhibition will be opened in Vienna on the 1st August next, and will remain open until the following 31st October. The office of the Organising Committee is at I Wallfischgasse 9A, Vienna.

ELECTRIC LIGHT IN BERLIN.—The Berlin correspondent of a daily paper says that during the festivities at the Old Castle (belonging to the Imperial Family) this season all the rooms are to be illuminated with the electric light. The work of preparation has already begun.

THE CHARING CROSS ELECTRIC RAILWAY.—The inhabitants of part of the district through which it is proposed that this railway and its extensions shall pass have resolved to oppose the scheme. They have called on the Lord Mayor to summon a meeting of citizens at an early date to consider the matter.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of December, 1882, were £1,346, against £1,458 in the corresponding period of last year. In December, 1881, the Bilbao cable was interrupted 15 days; in December, 1882, the Barcelona cable was interrupted 23 days.

ELECTRIC LIGHTING IN DUBLIN.—At a meeting of the Lighting Committee of the Dublin Corporation, held last week, the question of electric lighting was discussed, and it was unanimously resolved to engage the services of Mr. Angelo Fahie, C.E., of Dublin, as consulting electrician to advise the committee on the subject.

THE ELECTRIC LIGHTING ACT, 1882.—The Board of Trade have made the following rule, in pursuance of Section 5 of the above Act:—"The time provided for by Rules 4 and 11 of the rules made by the Board of Trade shall be the 1st day of February, instead of two months from the date of the newspaper containing the first advertisement of the application."

THE ROYAL SOCIETY.—The following paper by Lord Rayleigh and Mrs. Sidgwick was to have been read before this society on Thursday, viz.:—"Experiments, by the Method of Lorentz, for the Further Determination of the Absolute Value of the British Association Unit of Resistance; with an Appendix on the Determination of the Pitch of a Standard Tuning Fork."

APPOINTMENT.—Mr. George Carrick Steet, second medical officer to the General Post Office, has been promoted to be chief medical officer, in the room of the late Dr. Waller Lewis, and Mr. A. H. Wilson, the present assistant, succeeds Mr. Steet as second medical officer. We also understand that it is the intention to appoint a lady to take the medical superintendence of the female branches of the establishment.

ELECTRIC AND GAS LIGHTING AT SHEFFIELD.—At a meeting of the Electric Lighting Committee of the Sheffield Town Council, held last week, a report was read from Mr. Conrad Cooke, electrical engineer retained by the corporation to advise as to applying to the Board of Trade for a provisional order under the Electric Lighting Act, in which he recommended that the streets of the town should not be lighted by electricity but by gas.

BRITISH GUIANA.—The *Colonies and India* says that, according to the latest mail advices, it was announced in this colony that the Federal Council of the Leeward Islands had voted an increase of £1,000 per annum to the subsidy of the West India and Panama Telegraph Company. The local press, commenting upon this, considered that if similar concessions were made by the other West Indian colonies the Telegraph Company might yet get out of its present difficulties.

PURCHASE OF TELEGRAPH WORKS.—The directors of the Railway and Electric Appliances Company have concluded a provisional contract with Messrs. Latimer Clark, Muirhead, and Co., electric telegraph engineers and manufacturers, of Millwall and Westminster, for the purchase of their extensive works and business, as from the 1st January inst. The company secure the services of both Mr. Latimer Clark and Mr. Muirhead, the former as director and the latter as manager of this branch of the company's business.

ELECTRIC LIGHTING FOR CANTERBURY.—The Town Council of Canterbury have determined to endeavour to secure the

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insertion of clauses in the provisional order applied for by the South Eastern (Brush) Electric Light Company, providing that reasonable notice should be given to every consumer whenever the supply is to be taken off during the daytime, to retain full control over the breaking up of the streets, and that the works should be placed in a suitable situation, and at a place prepared by the city surveyor.

Lectures on Electricity.—A course of ten lectures on electricity will be given, at the instance of the Society for the Extension of University Teaching, by T. W. Waghorn, Esq., R.N., in St. Jude's School Room, Commercial-street, Whitechapel, E., on Tuesday, the 16th, and the nine following Tuesdays, at 8:15 p.m. The lectures will be illustrated by experiments and intelligible to beginners. Further information may be obtained from the hon. secs., F. Rogers, 62, Nicholas-street, Mile End, E., and A. Milner, 54, Claverton-street, S.W. The introductory lecture, on the 16th inst., is free.

To be Wound Up.—At a meeting of the Dublin Electric Light Company on Thursday week it was decided that the company should be voluntarily wound up, and an endeavour made to sell the company's plant and connection as a going concern. The company was formed in June, 1881, with a capital of £150,000 in £10 shares, of which 4,070 shares were taken up. A sum of £4 per share was called up, making a total of £16,280 subscribed. Mr. Gardner, of Messrs. Gardner, Craig, and Co., was appointed liquidator, and a committee of five shareholders requested to superintend the winding-up proceedings.

The Bradford Chimney Accident.—In consequence of the fall of a large chimney on Thursday, the 28th December, at Bradford (Yorks.), extraordinary pressure was suddenly put on the postal telegraph office there, and lasted for several days. Up to the 4th instant about 100,000 words had been signalled. On the day of the catastrophe about 20,000 words were forwarded from eight to ten p.m., all of which were disposed of by 10:30, although no previous notice could be given of the work. Direct communication was established with all the principal towns in the United Kingdom, including Aberdeen, Dundee, Edinburgh, Glasgow, Newcastle, Liverpool, Manchester, Bristol, Birmingham, Sheffield, Nottingham, London, &c. Considerable credit is, we think, due to the Bradford telegraph staff for the efficient way in which they have met this sudden call on their energies.

Electric Lighting at Newcastle-on-Tyne.—The *Newcastle Chronicle* says:—"Yesterday evening (Jan. 9) the steamer "Augusta," Capt. Arp, of Kiel, was discharged at Messrs. Davidson's wharf, Close, by the light given by a couple of electric lights carried on board the vessel. The lights—which are driven by the engines of the steamer—are placed in sex-angular lamps of medium size, fixed on at each end of the centre hold, in which the grain cargo is carried. The lamps are stated to be a Hamburg invention, and the company to which the "Augusta" belongs have seventeen of their vessels now supplied with them. The lamps seen at the Close last night have been in use on board the steamer for about a month, and the crew state that whenever they have been utilised they have given the utmost satisfaction. The lights, which are placed about 20 feet above the deck, are only used for loading and discharging purposes, and are never employed as signal or night lights at sea."

Exhibition of Incandescent Lighting in India.—The *Times of India* says:—"On the evening of the 21st December a large party of ladies and gentlemen assembled by invitation at Bella Vista, Cumballa Hill, the residence of Major Strutt, the managing director of the Eastern Electric Light and Power Company, to witness an exhibition of electric lighting on the incandescent principle. The interior of the bungalow, together with its spacious verandahs and the grounds adjoining were lighted by means of some fifty or sixty lamps of the Lane-Fox pattern, each lamp averaging about 20 candle-power. The lamps were arranged in a variety of ways so as to show the extreme adaptability of the light to domestic uses, and the result was a success in every way. The current was provided by means of a number of accumulators which had been previously charged with electricity at the company's works at Mody Bay, and conveyed to Cumballa Hill by coolies. One of the greatest novelties of the exhibition was the illumination of a fountain in the compound, the visitors being enabled, by means of a clever arrangement of lamps placed under water, to see with perfect distinctness the gold fish swimming about in the water."

Electric Lighting for the City.—At a meeting of the Commissioners of Sewers, on Tuesday last, Mr. Stoneham presented a report from the special committee appointed to consider the question of the electric lighting of the City, which recommended that the commissioners should apply under the Electric Lighting Act for a special license to light a small area and permissive powers for a larger area.—Mr Pannell inquired how the committee proposed to set about lighting the small area?—Mr. Stoneham said it was suggested that they might contract with a company.—Mr. Pannell pointed out the difficulty of the commissioners delegating their powers to a company, and, as an amendment, moved that the report should be referred back, particularly as no facts were given in the report for the court agreeing with their conclusion.—Mr. J. S. Scott seconded the amendment, urging that if they were to relegate to a company their powers they would be absolutely in the hands of one company.—Mr. Alderman Staples, who originally opposed such a proposal, said that he had altered his opinion, and he thought that if they found the light successful over the small area they might very well extend it.—After remarks from Mr. Waller and Mr. Borr, the report was adopted.

Electrical Exhibition at the Royal Aquarium.—We understand that Mr. Musgrave Heaphy, C.E., has been appointed to report upon the fire risk of the above exhibition, and that he has already inspected the installations as far as they have progressed, and given detailed instructions as to the safeguards to be adopted. All the electric companies will be glad to learn that it has been placed in his hands, Mr. Heaphy being not only a practical electrician himself, and having had the superintendence of large installations, but he possesses great knowledge and experience on all matters connected with fire risk, particularly that of hazardous buildings, a combination of knowledge at present absolutely unique. The fair and impartial course Mr. Heaphy has pursued towards electric lighting, while never losing sight of the interests of the fire offices, has created great confidence in the minds of the electric companies whose work he has had to officially inspect. His rules and regulations are too well known to need any comment here, but it is not so generally known that the fire risk of electricity is a very old study of his, and that as long as six years back he was called upon to report to the Phœnix Fire Office upon the matter, that being probably the first official report ever made upon the subject.

Slaughtering by Electricity.—A correspondent of a daily paper writes:—"The suggestion for rapid killing of animals by means of electricity has been actually carried out. Some years ago Dr. Richardson made use of the large induc-

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tion coil up in the Royal Polytechnic Institution for testing the question, and killed several sheep and other animals by the electric shock. The experiments led to results which were, to a certain degree, promising, and to a certain degree disappointing. The electric discharge always succeeded in striking the animals into instant insensibility, and in many instances the animals so stricken were positively killed; but in other instances, after the temporary production of all signs of death, there were indications of recovery, so that the death had to be completed by other means. It was found also that, when animals intended for human consumption as food were killed by the shock, some parts of the animal were marked by dark lines and spots, which to a considerable extent interfered with the sale of the carcases. Lastly, it was found that the dangers to the workmen attendant on the systematic introduction of the method into general use afforded an important reason for not recommending it. At the same time, the question remains *sub judice*, and the Council of the London Model Abattoir Society proposes to consider the electric with other painless methods of taking away the life of those members of the inferior creation which minister during their lives to our pleasures or our necessities."

The Yorkshire Brush Electric Light Company, Leeds.—This Company now appears to be securing a large amount of work, which, we understand, is fairly remunerative. As noticed in our issue of the 30th ult., they are lighting up the Theatre Royal, Dewsbury, and will continue to do so during the whole pantomime season under contract. As a direct result of their great success in the lighting of Dewsbury Theatre Royal, a similar contract has this week been signed for illuminating the Theatre Royal at Huddersfield, the Company using, as at Dewsbury, a patent headlight lamp for scenic effects during the "grand ballet" and other scenes. They have also received instructions to light up the underground markets of the Huddersfield Corporation, at Huddersfield, these markets being at present lighted throughout with gas; and, owing to intense heat, it has been decided to adopt the Brush system for illuminating the markets throughout. The Company are now busily engaged in fixing apparatus, &c., requisite for this work. On the 23rd inst., at the Town Hall, Huddersfield, Professor Allen, of Sheffield, will deliver a lecture on "The Philosophy of the Electric Light," when the large hall will be illuminated with Brush arc lamps, a system of switch arrangements being provided on the lecture table for demonstration purposes by the lecturer. Professor Rücker, of the Yorkshire College, is at present delivering a course of lectures on Electrical Science, at the Philosophical Hall, Leeds, and on Wednesday, the 31st inst., the Yorkshire Brush Electric Light Company will again illuminate the large hall by means of Brush arc and Lane-Fox incandescent lamps.

Electric Lighting in London.—The Mile End Old Town Vestry have adopted the report of their Special Committee on Electric Lighting, which was to the effect that "the knowledge of electric lighting is so slight that it is not advisable for the vestry to become undertakers under the Electric Lighting Act, and that the Board of Trade should refuse to sanction a provisional order for the next twelve months at least to enable proper consideration to be given to the matter." The Islington Vestry have, by a majority of fifty to eight, resolved to adopt the report of their special committee, as summed up in the following paragraph extracted therefrom, viz.:—"That in the existing state of electric lighting, and as far as the committee have been able to ascertain the probable costs of introducing the electric light into the parish, they are of opinion that it is undesirable that the vestry should become the undertakers." A committee of the Chelsea Vestry are considering the Metropolitan Brush Company's order for their district, and will report thereon soon. Messrs. Ferranti, Thomson, and Ince will not proceed with their order for this district, though they may take action in the matter towards the end of this year. The clerks of the St. George's-in-the-East and other vestries in the neighbourhood, such as Limehouse and Whitechapel, who are affected by the order of the Brush Metropolitan Company, are about to meet in order to take concerted action in the matter. They do not at present seem to be very favourably disposed towards electric lighting. The Camberwell Vestry, after a lengthy discussion, have resolved to oppose any application for a provisional order. As, however, the motion to apply for a license themselves was only negatived by 26 to 19 votes, it seems as if the prospects of electric lighting in Camberwell are not so very bad. The St. Olave's Board of Works have unanimously resolved not to apply to the Board of Trade for a license under the Electric Lighting Act. It was moved at a recent meeting to accept an offer made by Mr. Lane-Fox to light the district with incandescent lamps at a less cost than gas, but the question was adjourned for further consideration.

Electric Sparks and Electrostatic Actions.—The following is an abstract of a paper by M. Aug. Righi in the *Comptes Rendus*, published in a recent issue of the *Phil. Mag.*:—"Known experiments show that the electric discharge commences when the electric density on the electrodes has attained a sufficient value relatively to the dimensions of the balls, their quality, distance, &c. Supposing that the discharge is constituted by the emission of electrified particles, it will commence at that one of the two electrodes on which the density is the greater—from which we derive the explanation of many phenomena. If, then, at but little distance from the place where the spark is formed there are other electrified bodies, the particles will deviate from their path, moving away from the bodies which have charges of the same name as that of the electrode which repels them, and approaching the bodies charged with the contrary electricity. Now, the spark must pursue the path of the first particles repelled; for, by reason of the heat evolved, it offers less resistance. Therefore, the spark itself will deviate, as if it were a body charged with electricity of the same sign as that of the electrode on which the density previous to the discharge is the greater. The following is one of the ways in which I have verified this class of facts:—The two stems bearing the discharge-balls are arranged vertically one below the other, and at equal distance two parallel vertical discs are kept constantly charged, the one with positive, the other with negative electricity, by a Holtz machine with auxiliary combs, the exciters of which are sufficiently distant from one another for the sparks not to explode. It is readily observed that, when the two discs are not charged, the form of the spark produced between the two stems by the discharge of a condenser charged by another Holtz machine is nearly a straight line (if the distance between the balls is not too great); but if the discs are charged and if the two balls are not in all respects identical, the spark is curved, approaching the one or the other disc. The changes of shape are very remarkable when a liquid resistance such that the spark becomes yellow is inserted in the discharge-circuit. The spark then takes very curious forms, and at the same time it is observed to start from points of the electrodes situated laterally. Suppose, for example, that the two balls are identical in dimensions and

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quality, but that one of them, the negative, communicates with the earth; the greater density is then on the positive ball, and it is there that the discharge will commence. The spark, in fact, is displaced and deformed as a positively electrified flexible body would be. The same effect is obtained if, both balls being insulated, the diameter of the negative is greater than that of the positive ball."

Accumulators.—We have received a copy of certain "instructions" which the Electrical Power Storage Company, of 4, Great Winchester-street-buildings, E.C., have drawn up for the information of those using their accumulators. We extract the following items, which refer to the Faure-Sellon-Volckmar accumulators:—"The cells comprising the accumulator are composed of a certain number of positive and negative electrodes, the different plates of the electrodes being joined together, thus forming one single element. The plates are immersed in a solution of sulphuric acid of 1,250 degrees specific gravity. In all the cells the positive pole is marked with red and the negative with black colour. The electromotive force of each cell, irrespective of size, is 2·15 volts, and remains practically constant up to the economical point of discharge. If the discharge is continued beyond this point one or more cells must be added to the circuit to maintain the E.M.F. Where the accumulator is properly used, as hereafter described, the effective return is 90 per cent. of the electrical energy stored. Great care must be taken that, before the dynamo machine is connected with the accumulator, the poles of the dynamo are well ascertained. This may be easily done by making a simple voltmeter with two plates of lead put into a glass of water with a few drops of sulphuric acid. The positive pole is that of which the lead becomes immediately peroxidised or black. This must be coupled to the positive or red pole of the accumulator. The cells must be coupled the positive to the adjoining negative and so on, the red and black poles being coupled the one to the other. The last cell of the accumulator must be coupled, the black pole to the negative pole of the dynamo. To bring the accumulator to its normal state of activity it is desirable to charge and discharge twice at least in order to get rid of the sulphate of lead which forms on the plates when the accumulator is allowed to remain dormant. This also applies to cases where the accumulator has not been used for some time. Special care must be taken to have the accumulators well insulated, as any moisture being permitted to remain between the cells occasions a considerable loss of E.M.F. on the whole battery. Before switching the accumulator on to the dynamo the latter should be going at its full rate of speed, otherwise its E.M.F. would be less than that of the accumulator, which in that case would overpower the dynamo and reverse the current. Care must be taken to keep the plates entirely submerged. To always maintain the same E.M.F., 25 per cent. of the electrical energy which the accumulator is capable of receiving must be allowed to remain, and 75 per cent. may be withdrawn. For example, an accumulator composed of one h.-p. cells should at first be charged with 400 amperes of current; then, when 300 have been withdrawn, 330 should be put in again. This permits a further 300 amperes to be taken out, still leaving 100 amperes in the accumulator. The same proportion applies to the various sizes. The rates of economical charge and discharge of the respective sizes are as follow:—One h.-p. cells charge 20—25, discharge 30—40 amperes; two h.-p. cells charge 40—50, discharge 60—75 amperes; five h.-p. cells charge 100—125, discharge 150—175 amperes."

Mr. Edison.—A correspondent recently communicated some account of Mr. Edison's doings in New York to *The Times*. Most of what he has to say has been anticipated in our columns. We may, however, make the following excerpt from his communication:—"At the Edison Machine Works, at Goerk-street, New York, the dynamos, large and small, are manufactured. Six dynamos of the largest size were awaiting shipment to London; four were being prepared for Milan, where a central station on the Edison system is being organised by Professor Colombo. The factory of Bergmann and Co. is exclusively devoted to the manufacture of switches, fittings, sockets, regulators, and other details of the complete Edison electric light system. Here also the application of electricity as a motive power and lighting agent was manifested in an impressive manner. Mr. Edward H. Johnson, whose name is well known in London, together with Mr Edison, is continually at work improving the minutæ of the system. I was shown a simple screw, the sole survivor of forty-two separate and discarded models which had failed to satisfy Mr. Edison's standard of efficiency. As an example of American manufacture and administative power, the following is an instance:—An order to light the Boston Bijou Theatre with 650 lights was completed within eleven days after receipt of the order. The theatre was wired, the boilers and engine were placed in position, the streets excavated, and the special regulating system necessary for subduing the lights on the various circuits on the stage or auditorium not only devised and manufactured in New York, but used in position. The writer was present at the opening of the theatre when Gilbert and Sullivan's "Iolanthe" was produced, and all the necessary scenic effects obtained by the use of the Edison light alone. The theatre was better lighted than the Savoy in London, and the regulation of the lamps seemed to be under more immediate control. [Without in the least wishing to detract from the work of the Edison Company, we may remind our readers that this is the mere *ipse dixit* of an anonymous writer.] The feasibility of accomplishing this work in so short a time arose greatly from the absence of such municipal and legislative restrictions as in England impede the progress of electric lighting in every direction. During past years Mr. Edison has suffered from injudicious, because premature, revelations of his inventions, and for some time, therefore, he has remained silent whenever pressed for information as to the progress of his inventions. Some months have elapsed since the Edison system was first shown to the English public at the Crystal Palace, and, as is well known, it is in operation at various places. Since then Mr. Edison has, however, not been idle. He has made remarkable discoveries, the effect of which is greatly to increase the efficiency and reduced the cost of the light. These discoveries include a considerable improvement in the dynamos and the invention of a more economical lamp of very high resistance. It is interesting to know that the development of the capacity of the machines does not involve the disuse of any of its parts. Nothing is made obsolete. A simple and inexpensive addition increases, to use popular language, the electrical out-turn, and by the use of the improved lamp more light is obtained from a given quantity of electricity than is now the case. Patents for these and other improvements have already been applied for, both in England and the States, and the English companies will shortly give a public demonstration of the new inventions. Mr. Edison's knowledge of the conditions of the electric light question in England is complete. To his mind the price of gas in England is the one factor in the problem which requires solution. It is this problem to which he has applied himself with so much success."

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ELEMENTARY ELECTRICITY.

VI.

A number of Leyden jars whose coatings are connected together constitute a "Leyden battery," and serve for the accumulation of a large quantity of electricity at high potential, when they of course become the receptacle of a considerable amount of electric energy.

Suppose there are n jars, each of capacity C, and charged to potential V. The energy stored in each jar will be $\frac{1}{2}$ C V^2 ergs, and the whole energy of the battery will, therefore, be $\frac{1}{2}$ n C V^2 ergs. The charge of each jar will be C V units, and the whole amount of electricity communicated to the battery by the machine employed in charging it will be n C V units.

When it is required to charge a number of jars to a potential very much less than that which the electric machine employed is capable of producing, the "cascade" arrangement is sometimes adopted. For reasons which will presently appear, it is very seldom that this arrangement is of any real value, but as it is precisely similar to the arrangements of a voltaic battery or a number of "accumulators" in series, it is worthy of attention here.

To charge a Leyden battery in cascade, each jar, except the last, is placed upon a separate insulating support, and while the inner coating of the first jar is connected with the prime conductor of the electric machine, the outer coating is in communication with the inner coating of the second jar, the outer coating of the second is connected with the inner coating of the third, and so on, the outer coating of the last jar being put to earth. Suppose that there are six jars, and let them be called A, B, C, D, E, F. Suppose, further, that the opposite charges of the two coatings of each are numerically equal. This would be the case if the outer coating of the jar completely enclosed the inner coating, but in consequence of the projecting knob, &c., the charges are never quite equal in ordinary jars. Then if Q units of electricity enter the inner coating of the jar A from the electric machine, Q units of negative electricity will be induced on the outer coating of A, and, if we neglect the comparatively small charge of positive electricity which will remain on the outside of the outer coating of A, Q units of positive electricity will pass from the outer coating of A to the inner coating of B. Then, with the same qualifications as in the preceding case, we may say that Q units of negative electricity will be induced on the inner surface of the outer coating of B, and Q units of positive electricity will pass from the outer coating of B to the inner coating of C. Similar actions will take place between each pair of successive jars, and, finally, Q units of positive electricity will pass from the outer coating of F to the earth. (We have here spoken of Q units of negative electricity in order to avoid algebraical signs, but, in accordance with the one-fluid theory, we ought rather to have said — Q units of electricity.)

By this means we see that *all* the jars become charged with Q units of electricity, though only Q units are supplied by the electric machine. Had the jars been connected in the usual way, that is, with all their inner coatings connected together and all their outer coatings put to earth, to have charged each jar with Q units of electricity, it would have been necessary for six Q units to have been supplied by the machine; but we must not think that we have gained anything by the contrivance until we have investigated the potential of each coating.

The outer coating of the jar F is connected with the earth, and its potential is, therefore, zero. Let the potential of its inner coating be V, so that, C denoting its capacity, Q is equal to C V. Then, if all the jars are precisely equal in capacity, each will be charged to potential V, that is, the potential of the inner coating of each jar will exceed that of its outer coating by V. The potential of the inner coating of F is V, and the outer coating of E is connected with it. Hence the potential of the outer coating of E is also V, and since the potential of its inner coating exceeds that of its outer coating by V, it follows that the potential of the inner coating of E is 2 V. But this is also the potential of the outer coating of D, and D possesses the same charge—viz., Q units, hence the potential of the inner coating of D is 3 V. Similarly, we may show that the potentials of the inner coatings of C, B and A are 4 V, 5 V, and 6 V respectively. Hence the electric machine must be capable of producing a difference of potential between its prime conductor and the earth of *at least* 6 V *units*, and each jar can be charged to a potential only *one-sixth* that to which the machine could charge it by itself.

The energy of each jar will be $\frac{1}{2}$ Q V ergs, and the energy of the whole battery six times this, that is 3 Q V, and this is the electric work done in charging it. Suppose, now, that the inner coating of A is disconnected from the machine, and connected with the outer coating of F, all the other connections remaining undisturbed. The battery will then discharge itself, and Q units of electricity will pass across every section of the circuit. The case will be exactly the same as if a single jar of capacity only one-sixth that of each of the jars employed were charged with Q units of electricity, and, therefore, charged to potential 6 V, and the work done in the discharge will be $\frac{1}{2}$ Q · 6 V, or 3 Q V ergs, which is the energy of the battery.

Suppose that, the battery having been charged as before, the jars, remaining insulated, are disconnected from each other, and then placed with all their outer coatings connected to earth. Nothing will happen during this operation except the escape of the small free charge which is on the outside of the outer coatings of the first five jars, and which we have agreed to ignore, but the potential of the outer coating of each jar will, by the escape of this small free charge, be reduced to zero. The potential of the inner coating of each jar will then be V, and, being the same for each cell, the inner coatings may be connected together without any discharge taking place. The arrangement will then be equivalent to a single jar of capacity 6 C, charged to potential V with 6 Q units of electricity, and the work done in discharging it will be $\frac{1}{2}$ · 6 Q · V, or 3 Q V ergs, which is the same as before. A Leyden battery arranged in this manner may be said to be arranged *in multiple arc*, while the "cascade" arrangement may be said to be *in series*.

Suppose that one of the jars is charged to the full potential of 6 V. Its charge will then be 6 Q units, and its energy $\frac{1}{2}$ · 6 Q · 6 V, or 18 Q V ergs, so that if the electric strength of the glass is sufficient, a single jar may be charged so as to possess six times as much energy as the battery of six jars when charged in "cascade," or *series*, by the same machine. Of course, if the whole battery arranged in *multiple arc* be charged to the same potential, its energy will be six times that of a single jar, and, therefore, thirty-six times that of the same battery when charged in cascade. If the battery charged in multiple arc to the potential 6 V be discharged, the quantity of electricity which will pass in the spark will be six times the charge of each jar, that is 36 Q, while the length of the spark will correspond to a difference of potential of 6 V.

Suppose that the jars, having been charged independently, or in multiple arc to the potential 6 V, are placed on separate insulating stands, and then connected in series, the outer coating of F being put to earth, and its inner coating connected with the outer coating of E, and so on. Then each jar being charged to potential 6 V the potential of the inner coating of A will be 36 V. If the inner coating of A be now connected with the outer coating of F the whole battery will be discharged, but only 6 Q units of electricity will pass across each section of the circuit. The length of the spark will correspond to a difference of potential of 36 V. In this discharge, and in that last considered, the work done will be the same, viz.:—108 Q V ergs; but, with the battery arranged in multiple arc, the spark will be short and thick, corresponding to a transfer of 36 Q units of electricity, while,

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with the battery arranged in series (or cascade), the spark will be much longer and thinner, corresponding to a transfer of only 6 Q units of electricity. In the nomenclature of last half-century the former would be called an arrangement "for quantity," the latter "for intensity."

When, as in the case of the Leyden jar, glass is employed as the dielectric of a condenser or accumulator, it is found that a connection sustained between the armature for a short time only does not suffice for the complete discharge of the instrument. Thus, if a Leyden jar be charged, and a metallic connection made between its coatings, the jar will appear to have been completely discharged; but, after leaving it to itself for a few minutes with its coatings disconnected, the jar will be found to have acquired a feeble charge, and if it be again discharged and left to itself, in course of time a further charge will appear. This phenomenon is known as *the residual charge of the Leyden jar*. At first sight it seems as if electricity had soaked into the substance of the glass, and required a long time to find its way out again.

Maxwell showed that the residual charge could be explained by supposing that the whole of the substance of the glass had not the same insulating power, but that it contained strata scattered through its substance, across which electricity could pass, though very slowly. As long as the jar remains charged there will, then, be true conduction currents taking place across these strata from the inside towards the outside of the jar. The effect of this displacement taking place in the interior of the glass will be to retain some negative electrification bound upon the outer coating, and some positive electricity bound upon the inner coating of the jar, after a connection has been established between the two coatings, and this will continue until the electricity has had time to return across the badly-conducting strata. On account of the feebleness of the force causing the return of the electricity, after the jar has been discharged, a much longer time will be required for the return journey than was occupied in the original displacement.

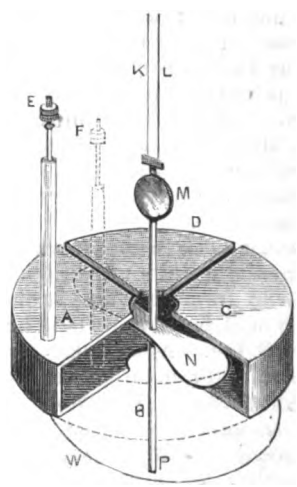
A phenomenon very analogous to the residual charge of the Leyden jar may, however, be observed in connection with the elastic properties of bodies. If a glass fibre be twisted and then allowed to free itself from the torsion, it will not return to its orginal condition at once, but, having in its first effort relieved itself of most of the twist, it will untwist itself through the remaining angles, only with extreme slowness, and, in the course of weeks, or even months, will not have returned to its original form, so that it is hardly too much to say that its condition at any time depends upon the whole of its past history. It is well known, too, that glass after being strongly heated does not at once return to its original volume on cooling, and Dr. Joule found that the zero of some of his thermometers continued to rise from this cause for more than twenty years. If we regard the energy of a charged conductor as due to an electric strain in the dielectric, we at once recognise a connection between these phenomena and the residual charge of the Leyden jar.

On the Quadrant Electrometer.

As previously stated, the immediate object of an electroscope is to *detect*, and of an electrometer to *measure* differences of potential. The gold leaf electroscope belongs to a class of instruments called by Sir Wm. Thomson *idiostatic*, because they contain no charge of electricity which is independent of the bodies whose difference of potential they are called upon to detect or measure. Such instruments can never be rendered very delicate, for when the difference of potential to be examined is very small, the charge of every portion of the instrument will be correspondingly small, and all forces called into play will be reduced in proportion to the square of the difference of potential between the electrodes of the instruments.

The quadrant electrometer belongs to the class of *heterostatic* instruments which contain a charge of electricity foreign to and independent of the bodies to be examined. As this charge can be increased to any extent consistent with the insulation of the instrument, the forces called into play can be made sensible even when the differences of potential are very small, these forces being, for any given charge of the instrument, proportional to the difference of potential to be measured, and not to the square of the difference.

The essential parts of Sir William Thomson's quadrant electrometer are represented in the accompanying figure. The needle N is a piece of thin aluminium, which is frequently corrugated to increase its stiffness. A small mirror, M, is rigidly attached to the needle so as to turn with it, and the whole is suspended by means of two single silk fibres, K L, the distance between which at the top can be regulated by means of a screw. This constitutes an ordinary bifilar suspension, the weight of the suspended body tending to cause it to set itself so that the two silk fibres are in the same vertical plane. From the bottom of the needle hangs a platinum wire which dips into strong sulphuric acid, which is contained in a glass vessel. The lower portion of the exterior of the glass vessel is partly covered with tinfoil, and this, with the inner coating of sulphuric acid, constitutes a Leyden jar, and serves to accumulate a large charge of electricity when the needle is charged. The sulphuric acid also keeps the instrument dry. The needle N is placed within a brass box consisting of four quadrants, A, B, C, D, each supported on an insulating glass pillar; but the quadrants which are diagonally opposite, viz., A C and B D, are connected by wires, of which the wire W, connecting the quadrants A and C, is shown in the figure. The quadrant B has been removed in the figure in order to show a portion of the needle. The binding screws in connection with the quadrant A and B form the electrodes of the instrument.



Sir W. Thomson's Quadrant Electrometer.

Before using the electrometer a positive charge is communicated to the needle N, the Leyden jar serving as a storehouse, from which the charge of the needle is replenished as it slowly escapes. A positive charge is preferable to a negative charge, because it is less quickly dissipated from the edges of the needle. The charge is communicated to the needle through an electrode which is made to touch the wire P, or to dip into the sulphuric acid in the jar. Before charging the needle, however, the bifilar suspension is so adjusted that the needle under the influence of the suspension and its weight alone takes up a position so that its axis is parallel to one of the divisions between the quadrants. While the needle is being charged all the quadrants are connected by a wire uniting the electrodes of the instruments. Then, after charging the needle, its position of rest should be the same as before. If this is not the case, there is a want of symmetry about the instrument which can be corrected by causing one of the quadrants, which is made movable for the purpose, to approach or recede from the centre by means of a screw. When the instrument has been properly adjusted the needle, though strongly charged, continues to point in the same direction as before. Now, suppose that the electrodes being disconnected from each other, the quadrants A and C are connected with the positive pole of a battery, and the quadrants B and D with the negative pole. Then, since the positively charged needle will always tend to pass from places of high to places of lower potential, it will tend to turn out of the quadrants A, C, and into the quadrants B, D. This tendency

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will be resisted by the bifilar suspension, and the needle will take up a position in which it is in equilibrium under the action of the two opposing couples, and for *small* differences of potential the deflection of the needle will be *proportional* to the difference between the potentials of the two pairs of quadrants. The deflection of the needle is registered by means of a beam of light which is reflected from the mirror *m* and received on a graduated scale.

The quadrant electrometers made in Glasgow are furnished with an "idiostatic gauge," which indicates when the electrification of the needle has attained a certain degree, and thus enables us to keep the needle always charged to the same extent, and renders the observations made on one occasion comparable with those made at other times. It is also furnished with a "replenisher," by which the electrification of the needle can be slowly increased or diminished; but these portions of the instrument will be referred to later on.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

XII.

The operation of testing the joints in a cable is one that all assistants in a testing room should be able to perform, although the duty is, as a rule, confined to those employed in a cable factory. Some authorities are of opinion that this test is not so very important, whilst others maintain that it is of the greatest use. It is certainly included in the routine of testing in the various works, but among those electrical engineers who act as inspecting agents for the different companies there are some who have discontinued the practice of testing joints specially, considering that the insulation and capacity tests are sufficiently comprehensive to insure the safety of these points in the sentence which they pronounce on the cable generally.

A joint is a very critical portion of a cable, so many causes combining to make it difficult to insure perfection. A weak joint, in an insulating point of view, is like a bad link in a chain, it affects the quality of the whole length, and it must be remembered that there are some hundreds of them in a long cable, such as those between England and America.

As regards the value of a special joint test, it is said by those who do not consider it essential, that if an insulation test, applied at a proper time after the joint is made, gives the ordinary satisfactory results, there is no doubt that all is right, and that if any evidences of a fault are seen on first testing after manufacture it is safe to assume that the joint is the seat of it. They also say that the test is not *per se* conclusive, and it is true that a joint has been known to pass through the ordeal of the special test and yet to have afterwards proved to be imperfect; so that the reputation of the jointer who makes the joint is to some who are aware of this fact the best guarantee for its excellence where he is known to be a first-rate hand.

Without venturing to say that the joint test is altogether as satisfactory as some other tests, we would suggest that it is yet very useful, and that by taking every possible precaution, and carefully arranging all the details, leaving nothing to chance or possible neglect on the part of any one concerned, a weak joint will be detected, and we are at least sure that it has not gone though the machine, and so the evil is as small as possible. We make these remarks to impress on the learner the advisability of being particularly careful not to think this test a mere perfunctory duty; for here, perhaps, more than in other operations he ought to know what he is doing—that is, if the test is to be worth anything.

The goodness of a cable joint depends upon its insulating quality. It is made entirely by hand, and should be nicely rounded, and made as nearly as possible of the same dimensions as the core itself. It cannot be exactly the same, because the ends of the copper conducting wire must overlap each other, and are bound with other (fine) wire before being covered with gutta percha or other insulator employed in that core. The object being to test one short portion only of the cable, say eight inches indeed, particularly excluding every other item of its length if possible, some means in addition to the ordinary appliances for an insulation test must be adopted. Moreover, we have to test a section which has no end free—that is to say, the two ends of the joint are merged in the whole length, as far as it is concerned, and the only means of escape for any electrical charge (excluding all the rest of the cable from the consideration) is the insulating cover which has been laid on by the jointer. The charge, of course, is effected by connecting a battery to one end of the conductor, and the other end, or the end of the last length of core which has been joined on, is left hanging free, or sealed over, so as to be well insulated, as in the insulation resistance test. The learner will understand that these joints are made between the various lengths of core as they are united to the sheathed portion of the cable, or, more particularly, when a length is so far sheathed that a comparatively small portion is left behind the sheathing machine, a fresh drum of core is joined to this remnant in good time, that no unnecessary stoppage shall take place. These are called cable joints, as distinguished from what are termed "manufactured" joints, these latter being made during the preparation of the core in the "core department," and before it is wound on the drum. As a rule the "manufactured" joints are not tested on the "cable" side, though occasionally they are passed in the cable testing room; but they must be carefully distinguished from the cable joints when entered in the joint book, for reasons which will appear later.

We are only concerned here with the fact of the joint being made, and need not go into detail on the operation. It is necessary, however, to state that it is kept in water for some hours (generally six or eight) after it has been finished, and should not be tested till that time has expired. When made it is placed at the bottom of a trough containing water, this trough being mounted on an ebonite stand, and thus insulated.

The object of the test is to send a charge into the joint, and by maintaining this charge for a certain period, to discover whether the insulation is sufficiently good by noting the proportion in which leakage is permitted. So far it resembles an insulation test, except that we do not measure the resistance; but the leakage of charge is not allowed to pass directly to earth. It is caused to accumulate for the time fixed, and is then discharged through a galvanometer. In this part of its course it resembles the capacity test.

The means for observing the leakage through the covering of the joint is afforded by our former friend the condenser, which is brought into communication with the water in the trough, and collects whatever accumulation of electricity there may be due to that cause. This is afterwards discharged through the coils of a sensitive (mirror) galvanometer, and estimated in the manner explained in the capacity test, that is, by the deflection which appears on the scale.

There are various ways of joining up the different appliances for this test, and it can be taken either with a galvanometer or an electrometer. We shall show how to perform both operations, commencing with the former instrument. It will be as well to give two or three diagrams of connections for this first operation, beginning with one which sets forth the arrangement in a manner involving more connections than are absolutely necessary for the test, but these connections have been actually used in the joint-testing of many cables, and they show the principle and working of the operation more clearly than other arrangements which are more concise, though of course they are one and the same in their application.

This method of joining up for the test is shown in Fig. 23. A dividing line separates the portion outside in the cable shop and tank house from the connections in the testing room.

The pieces marked F and G are in the first place connected, the one to the cable (by the copper conductor) and the other to the trough. To the former, F, two separate connections can be made, that at A with earth and that at B with the battery. Thus, by depressing A alone the conductor of the cable would be put to earth; by depressing B alone it would be charged. Similarly, G has two separate contact pieces. C being put down connects the trough with the

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galvanometer, and D, if put down, connects it to the condenser. If C and D were depressed at the same time, the condenser would be made to communicate with the galvanometer, and any charge which it contained would be discharged through the latter to earth. The earth connections are drawn separately here, but in practice they would probably be all joined to one earth wire. The learner will remember our remarks on the condenser in No. VI., and knows, therefore, why one pole of the condenser is put to earth. We shall see presently how the fact of the necessity for doing this helps to explain a feature in another arrangement of the joint test where no earth at all is used for any part of the circuit. This will come in its proper place presently. We will first give the outline of the test as now suggested, and afterwards the practical execution will be shown.

The trough containing water has two little hooks at the bottom to secure the joint, and is itself either a metal bath on an insulated stand, or if it be of insulating material as some forms are, it has a copper plate resting inside to which the leading wire connecting with the key G is joined. In the former event this lead is connected to the rim of the trough. In either case the object is to bring the key G into conductive communication with the water. If, now, B is depressed a charge enters the cable, and, of course, the joint also. We may regard the circuit as starting from one battery pole through the copper conductor and through the insulating cover of the joint to the water, but this being insulated leaves the circuit incomplete. The arrangement so far resembles the attempt to charge one pole of a condenser from a battery having one pole to earth, the condenser's other pole being insulated. But if D were depressed at the

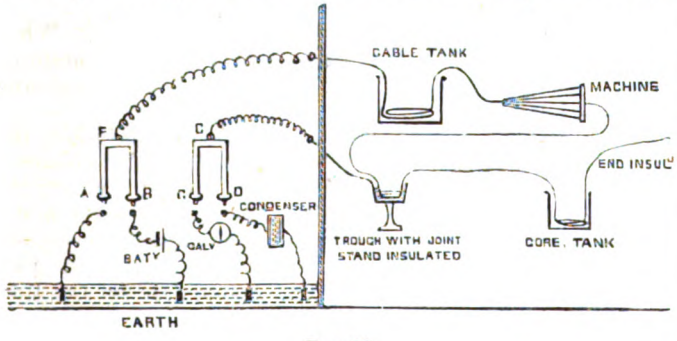

FIG. 23.

same time as B, the condensor is joined up to the trough' and any electricity leaking through the joint would pass to one side of this accumulator, which would retain the charge until, on putting down C, it would be discharged through the galvanometer thus connected to it on one side and to earth on the other.

In speaking of this course as a circuit we must recall to the learner's attention the remarks in Nos. VI. and VII., where the condenser was discussed. Referring also to the insulation resistance test in No. IX. we desire to remind him that the view of its conditions there suggested was proposed as being the simplest that he could take at the time; and it seems necessary to observe that the apparent difference in the principles involved in these different tests is *only* apparent. It will be safest to regard the joint test as in one view resembling an insulation test, and in another being more like that for capacity, and to consider the action as involving a charge by which an inductive as well as a conductive circuit is produced. If the condenser were cut off from the trough through the key D being raised there would be facility of accumulation as far as the joint is in question. The charge being continued from the battery would be acting throughout the length of the cable as in the ordinary insulation test, and we could not say there is any current through the cover of the joint. As a matter of fact, the key D is kept down all the time that the battery is charging the cable, and whatever quantity of electricity accumulates in the condenser certainly comes from the joint. The rest of the cable is, no doubt, under water in its tank except that part which is being sheathed, and that which is only core, but we need not regard this at present. There is no supposed question of the leakage at any point except at the joint. When C is put down the galvanometer will show by the deflection whether the leakage is too great, a limit being fixed which ought not to be surpassed. The depression of the key A after this will finally discharge the cable, the battery being previously taken off by releasing B. This outline must now be filled in by going more in detail through the test, in which there are other features of importance also concerned with points which have given rise to various opinions on its theory.

Whilst the plan of connections in Fig. 23 is very simple, it is possible that the arrangement on the table may not outwardly resemble it. But if the operator had to join up the various parts himself, he would easily find the points which we have marked with letters, even if the other details were covered. By remembering the relations between the several points, and where each should lead to, no difficulty need remain.

Like the other tests which have been considered, this is comparative, and a well-defined standard is fortunately provided. It is agreed that a joint shall prove as good in point of resistance to leakage as (say) six feet of the core with which it is united. When a piece of this length is submitted to the test before us a certain deflection is produced on the scale, and the joint must not cause a larger deflection when tested in its turn. As regards the number of divisions allowed for this deflection the limit will depend on the sensitiveness of the galvanometer. This, again, is controlled by the position of the large directing magnet above the cover, and also by other considerations. In practice the beginner will find all this properly prepared. Some electricians arrange for a deflection of 1 or 2 divisions only with certain cores, and others prefer a wider range; we cannot fix any definite limit here. In the next number we have to consider the test as it would be gone through practically, referring to Fig. 23 for fuller explanation where any diagram shows only a part of the connections.

CROMPTON'S COMPOUND MACHINE.

BY GISBERT KAPP.

(CONTINUED FROM PAGE 155.)

In order not to complicate the question more than necessary, we will assume the field to be separately excited, and always to the same intensity. If no current traverses the armature there will be no curl distorting the primary lines of force, and no secondary lines of force at all. The points of greatest polarisation in the revolving Gramme ring will be shifted forward by a certain angle on account of the time required by the iron to take up and lose magnetism; but, as Breguet's experiments show,* this angle is very small, and, being constant for all currents, need not be further taken into account.

We will also assume that the core (as should always be the case in a well designed machine) is so constructed that local currents in itself, the curl from which might shift the field, are avoided. Under these conditions we find, then, that the diameter of commutation should be very nearly horizontal, and if the brushes were set with a certain lead we should expect them to spark heavily. Experiment shows, however, that this is not the case. The apparent anomaly can easily be explained if we remember that the so-called neutral points (that is, those points where the number of primary lines of force is a maximum) in the Gramme ring are in reality not points at all, but zones of some extension, and consequently a certain variation from the theoretically best position of the brushes can be allowed.

The presence of these neutral zones must in so far be regarded as an evil, as the coils that pass them, whilst contributing their full share to the total resistance of the armature, contribute nothing to its electromotive force. But the evil is a necessary one, for if an attempt were made to reduce the neutral zones to two points by extending the pole pieces, so as to envelop more of the circumference of the ring, it would be found that some of the primary lines of force,

* See *Electric Illumination*, p. 86.

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instead of deviating into and out of the ring, run straight across between the extended pole pieces, and are thus lost.

That this is actually the case the author has recently had occasion to prove by an experiment upon a Bürgin machine, the electromotive force of which was increased by 9 per cent. (from 75 to 83 volts) through cutting a quarter of an inch off the extension of pole pieces.

Admitting, then, that a neutral zone is a necessity, our primary curve (see Fig. 4, page 155) is not correct, but should be more of the shape shown in Fig. 5. It will be seen that as long as the brushes are shifted within the neutral zones represented in the diagram by the spaces where the curve coincides with the axis of abscissæ, no appreciable change in current or electromotive force will take place. Anywhere within that space the brushes are in the right position. The same holds good if a very small current be allowed to traverse the armature, for there will be so few of the secondary lines of force that their curve can practically be considered to coincide with A X.

The area contained within the primary curve and the axis of abscissæ gives, therefore, without any deduction, the electromotive force between brushes B_1 B_1.

If, now, a moderate current be allowed to flow through the armature two things will happen. The primary curve will be shifted forward in the direction of movement, which in the diagram is equivalent to shifting the brushes to the left, say to B_2 B_2; and the secondary curve, instead of coinciding with the axis of abscissæ, will deviate from it above and below. The electromotive force is now represented by the area contained between the two curves. Something has been added to and something subtracted from

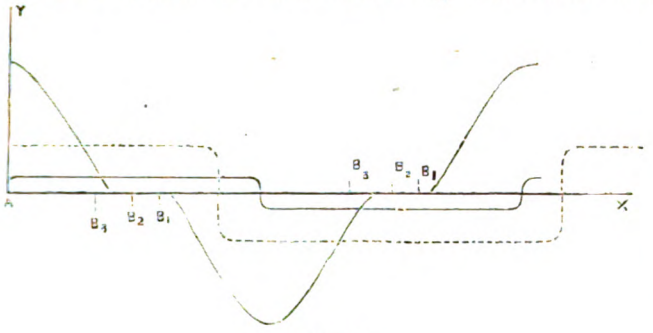

FIG. 5.

the area which represented it before. From the diagram, which it must be remembered is not to scale but merely an illustration of the idea, it would hardly be safe to predict whether the total result will be an increase or decrease of electromotive force. Roughly speaking, we may expect that, with moderate currents, the total effective area will not be materially altered; for, as long as the field is only slightly shifted and the brushes remain within the neutral zone, the secondary curve, which must necessarily be of the somewhat rectangular character shown in the diagram in a full line, adds as much on one side as it takes away on the other.

With very heavy currents, however, the case is different. The field gets shifted to such an extent that the brushes come to stand outside the neutral zone on the inclined part of the primary curve, say at B_3 B_3; and in this position the area subtracted by the secondary curve (dotted in Fig. 5) exceeds that added.

If the reader will take a piece of tracing paper, draw on it a secondary curve, and shift it along A X, he will get a very clear idea how the electromotive force varies with different degrees of distortion in the primary field.

If the above reasoning be correct, we should expect to find that in a separately excited field the electromotive force in the armature is very nearly independent of the current as long as the latter remains within moderate limits, but that it decreases as soon as the current is allowed to increase beyond these limits.

And this is exactly what happens in practice.

Fig. 6 represents the characteristic curve of an ordinary Bürgin series dynamo (not a compound machine), designed for a maximum current of 40 amperes. Scale of diagram:—1 volt and 1 ampere equals 1 millimeter, but to economise space the ordinates are drawn too short by 100 volts. If we now excite the field of this machine separately and to the same intensity as represented by the abscissæ of the characteristic curve, and measure the electromotive force of the armature, but without taking any current from it, we find a new characteristic curve which coincides with the former curve for all currents between nine and seventeen amperes, but beyond that rises considerably above it. It must here be remarked that in determining these curves experimentally, care must be taken to keep the speed of the machine as constant as possible. But, in spite of all precautions, slight variations in speed will very often occur. The reading for E.M.F. must then be corrected by assuming it to be proportional to the speed. This is correct if done within reasonable limits.

It was shown in the beginning of this paper that to maintain a constant difference of potential in the external circuit E a, the electromotive force in armature should increase with the current. But now we find that instead of doing this it actually decreases if the field be kept constant. This behaviour is very inconvenient for regulation, and the question now arises, how can the evil be avoided or minimised? The theory of primary and secondary lines of force, as developed above, supplies without further need for investigation an answer to this question. There are two remedies. We can either keep a small neutral zone, and prevent excessive distortion of the field, or allow the distortion and provide a neutral zone wide enough for it. In practice I have found a combination of both to give the best results. Distortion of the

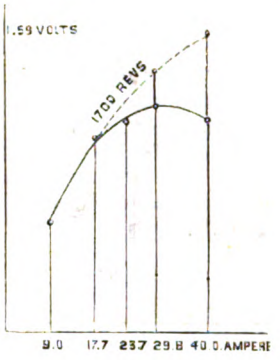

FIG. 6.

field can only be prevented by putting more primary lines of force into it, and this again requires that there should be more iron than usual in the pole pieces and arms of field magnets. In the Crompton compound machine, this is done by making the arms twice as long as those of an ordinary Crompton-Bürgin machine, and the pole pieces by about 30 per cent. heavier. The increase of length has also this advantage, that it is possible to obtain the necessary excitation (ampere turns or coil amperes) with a thicker wire, and as for equal ampere turns the resistance is inversely proportional to the weight of copper employed, it follows that the lengthening of magnets has the additional advantage of reducing their resistance.

Let R be resistance of armature, r that of main coils and external circuit, ρ that of shunt coils; and let c be the external, γ the shunt, and $C = c + \gamma$ the total armature current, then we have

$$E\,b = r\,c = \rho\,\gamma.$$
$$E\,a - E\,b = R\,C$$
$$E\,b = \frac{E\,a}{R\left(\frac{1}{R} + \frac{1}{r} + \frac{1}{\rho}\right)}.$$ *

If the main current is led in n turns round the field mag-

* If we suppose $\rho = \infty$, that is an infinite length of shunt wire, the above formula can be simplified to $E\,b = \frac{r\,E\,a}{R + r}$, which is that given by Mr. Bosanquet. This formula is, therefore, only correct if it be permissible to neglect altogether that amount of current which goes through the shunt coils. In ordinary cases this amount is, however, too large to be neglected.

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nets its existing power can be expressed as $n\,c$ ampere turns. Similarly, if the shunt current is led in v turns round the field magnets its share in the work of exciting can be expressed $v\,a$ ampere turns.

The intensity of magnetism will therefore be a function of

$$\text{ampere turns} = n\,c + v\,\gamma;$$

or if we eliminate c and γ,

$$\text{ampere turns} = \left(\frac{\mathrm{E}\,a}{\frac{1}{\mathrm{R}} + \frac{1}{r} + \frac{1}{\rho}}\right) \cdot \left(\frac{n\rho + v r}{\mathrm{R}\,r\,\rho}\right)$$

From this formula it will be seen that the exciting power of both coils is directly proportional to the electromotive force in the armature, and as that itself is a direct measure for the magnetic intensity of the field, we can say that in a given machine, as long as all resistances remain unchanged, the ampere turns are a direct measure for the electromotive force. If, for instance, the E a for a certain speed and ampere turns were known, then by inserting dynamometers or ammeters into the shunt and main circuit, and observing both currents and corresponding ampere-turns for different speeds, the electromotive force due to each speed can easily be calculated. In this respect the compound machine is exactly like a series dynamo.

If we now assume that the external resistance r varies, the case becomes at once very complicated. In the first place, the ampere turns are altered, and, consequently, the exciting power; this affects the intensity of the magnetic field, but not in a simple ratio. The nearer the field magnets are to the point of saturation the smaller will be the influence of a variation in the exciting power, but, whatever the amount, it affects in a direct ratio the total electromotive force, which in its turn again alters the exciting currents until, by a system of mutual reaction, a state of equilibrium is again established. The action is so complex that there is very little inducement to investigate it analytically, as only a maze of most complicated formulæ, with no visible way of solution, can be expected; but, by resorting to a graphical method, the investigation is in no way difficult.

(TO BE CONTINUED.)

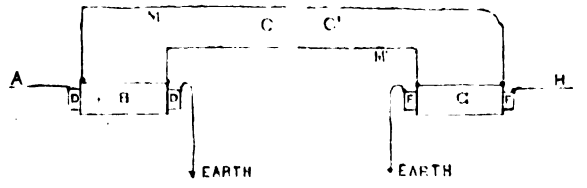
LONG-DISTANCE TELEPHONY AND BENNETT'S TELEPHONIC TRANSLATORS.

Shortly after the Postmaster-General had won his famous test case against the United Telephone Company, licenses were granted to the various companies throughout the United Kingdom to open local exchanges, but the privilege of joining the systems of two or more different towns was absolutely denied them, however important or desirable communication between them might chance to be from a commercial point of view.

The exchanges opened by the National Telephone Company in Glasgow, Greenock, Dumbarton, Paisley, Hamilton, and Coatbridge may be taken as an illustration of the difficulty. The business relations between these centres are of the most intimate nature, it being not uncommon for one firm to possess branch works or offices in two or more of them, and daily customers in all, and yet the company was not permitted to erect anything but local exchange lines.

But after some negotiation the Post Office consented to provide trunk wires on their own poles between the various exchanges, stipulating that a separate trunk wire should be erected for every eight subscribers desirous of availing themselves of the privilege, and for every trunk wire the company should pay the Government an annual rental of £320 between Glasgow and Greenock, £104 between Glasgow and Paisley, £128 between Glasgow and Hamilton, and £120 between Glasgow and Coatbridge. Subsequently a trunk wire was projected between Glasgow and Edinburgh, for which the Government tax was fixed at £560 per annum. Similar arrangements were made for Leeds, Bradford, Huddersfield, Birmingham, Wolverhampton, and other important towns, and, notwithstanding the heavy rates which the Government tax rendered necessary, amounting in the case of Edinburgh to no less than £110 per annum for each subscriber, the leading manufacturers and merchants were not slow in taking advantage of the opportunity of obtaining free communication with their distant works and customers. But now arose a difficulty which, perhaps, may have been overlooked by the Post Office electricians, and certainly by the officials of the National Telephone Company by whom the negotiations were conducted. Being erected on the same poles as the ordinary telegraph wires, the new trunk lines would obviously be greatly affected by induction. This was recognised, and it was agreed to run metallic circuits on the principle first suggested by Professor Hughes, and first given practical effect to by Messrs. Moseley and Sons, of Manchester. This plan was, of course, known to be effective in neutralising the effects of induction from neighbouring telegraph wires, but until the contract with the Post Office was nearly, if not quite, completed, no person had considered how the extremities of the metallic loops forming the trunk lines were to be connected when required to the subscribers' single local wires.

Putting the metallic loop to earth anywhere would be to destroy its efficacy, while it was quite impossible on the score of expense to run metallic loops for the local subscribers, as that would mean doubling the company's already crowded systems. When the terms of the contract came to the knowledge of Mr. Alfred R. Bennett, engineer to Messrs. D. and G. Graham, the National Telephone Company's engineers and contractors for the Glasgow district, he pointed out the hitherto unseen rock ahead, and was requested to devise a means of overcoming the difficulty. In May, 1881, Mr. Bennett began to experiment, and, after trying several plans, patented the only one which promised success. This consists of a system of induction coils of peculiar construction, arranged to repeat or translate the telephonic pulsations to and from the metallic loop without putting it to earth at any point. Having induced currents of small quantity to deal with, it was evident that coils having primaries of the usual thick wire and small resistance would not answer. Coils with primaries and secondaries of equal gauge and resistance were therefore tried, but it was afterwards proved that the best results were obtained from coils having a resistance ratio of 1 to 2·6. The connection between the metallic circuit and the single wires may be understood from the annexed figure:—



A leads to switchboard and subscribers. B indicates Glasgow Exchange.
C C' is a metallic loop 50 miles long. G indicates Greenock Exchange.
H leads to switchboards and subscribers.

One of the coils of the translator at the Glasgow Exchange is connected by means of the metallic trunk loop, which in this case has a total length of 50 miles, with one of the coils of the translator at the Greenock Exchange. When a Glasgow subscriber wishes to speak to a Greenock subscriber their respective single wires are joined to earth through the switch-boards and the disengaged coils of the translators. The speaking is then transmitted in the following manner:—

(1) The current arriving at the Glasgow Exchange from the first subscriber's wire A passes through the coil D D of the translator to earth; and

(2) Induces in the other coil B of the translator similar currents, which pass over one wire of the metallic loop through the coil G of the Greenock translator, and back to Glasgow by the other wire of the loop; and

(3) Induces similar currents in the other coil F F of the Greenock translator, which pass away to the second subscriber's wire H, *viâ* the switch-board, and to earth through

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his telephone, the other end of the coil F F being to earth at the exchange.

M and M′ are magneto-electric calls and bells, inserted one in each wire of the metallic loop, for the purpose of enabling the exchanges to attract each other's attention.

Although some diminution in the loudness of the speaking results from the double transfer by induction to and from the metallic loop, this can be compensated for by speaking closer to the transmitter, or more distinctly than is usual on local lines; or by using two or more cells joined for quantity on the transmitter instead of the ordinary single cell. Curious features of this apparatus are that the current is changed no less than four times between the speaker's transmitter and the listener's telephone, and that induction is successfully used in one form to combat the evil effects of the same phenomenon in another. In the Glasgow district the invention, which is now the property of the Electromotive Force Company (Limited), has been working successfully for about nine months, and for a shorter period in Staffordshire, Warwickshire, and Yorkshire. Its sphere of usefulness will, doubtless, enlarge as telephonic intercommunication between distant towns becomes more common.

THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 178.)

In the figures already given, we see the general action which takes place when trying to work through a long submarine cable, or subterranean wire. When a battery is applied at A an appreciable time elapses before the current at B arrives at its maximum, and even if we can work with the current arriving at B before it arrives at its maximum a certain time must elapse. Then, if working with a single current, a certain time elapses before the dynamic charge is discharged, and during the discharge the current at B continues to flow, though getting less and less, as shown by the

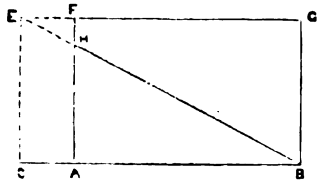

FIG. 42.

curves, thus continuing the signal after we wish it to cease. By sending a reverse current the charge is, of course, more rapidly neutralised, a system always adopted. The proportion which the dynamic charge, when the current has arrived at its permanent state (or maximum at B) to the total static charge the line would take, with the same battery, if the distant end B is insulated, is shown in Fig. 42, where C A is the resistance of the battery, C E the electromotive force, A F C B would be the charge with the end insulated, and A H B the dynamic charge when the end is to earth. Thus, if we call R the resistance of the line, r the resistance of the battery, and E the electromotive force, then as we suppose the electrostatic capacity to be proportional to the resistance, E by R would be the static charge, the charge in this case being independent of the resistance of the battery. For the dynamic charge we must find the potential at A, and we have B C $(= r + R)$: C E $(= E)$ :: A B $(= R)$: A H $(=$ P potential at A when B is to earth); or, in fact $\frac{E.R}{r + R} = P$, and evidently A B × A H divided by 2 is the triangle A H B. Whence $\frac{E R}{r + R} \times \frac{R}{2}$; or $\frac{E R^2}{2 (R + r)}$ equals the dynamic charge in terms of the static charge.

If the battery resistance is very small in comparison to any two lengths of similar wire, then the dynamic charges in them with the same battery will be nearly directly as their lengths as seen in Figure 43, where C A is battery resistance, C E electromotive force, A B one wire, and A D another. The charge in A B is A F B and the charge A D is A G D.

If, on the contrary, the resistance of the battery is very great in proportion to the resistance of two different wires, then it will be seen that the charges are nearly to one another as the squares of the lengths. For by Fig. 44 the greater C A is in relation to A B and AD the more nearly lines E B and

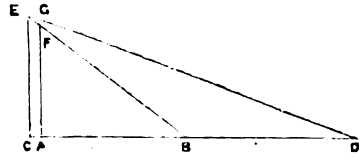

FIG. 43.

E D approach to parallelism, and if those lines were parallel, then the triangles A F B and A C B would be similar, and consequently proportional to the square of their homologous sides, or, in fact, to the squares of their lengths.

If the current is the same in two wires of different lengths, but similar type, then the dynamic charges will be exactly as the squares of their lengths, as seen by Fig. 45. When A B and A D are two wires, C E being the electromotive force of the battery applied to A B and C A its resistance, C′ E′ the

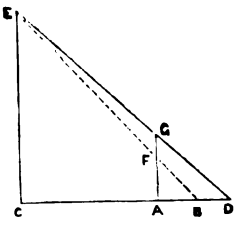

FIG. 44.

electromotive force of the battery applied to A B, and C′ A its resistance—these electromotive forces being made proportional to the two wires, so as to produce the same current in each—then the line of potential in A D will be G D and in A B it will be F B. The charge in A B is A F B and in A D A G D. And as F B and C D are parallel (since they represent the same current) by the reasoning before given these charges are to one another as the squares of their lengths.

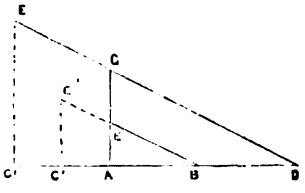

FIG. 45.

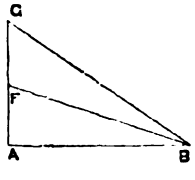

FIG. 46.

In any one wire the dynamic charge will be directly as the *current* producing it, as seen by Fig. 46, where, if the potential line of the larger current is represented by G B and the lesser by F B, the currents are evidently directly as the potential at A, no matter how that potential is produced (as regards resistance of battery, &c.), and the charges are as these potentials A F and A G.

WESTERN UNION TELEGRAPH COMPANY.—The Union Trust Company of New York give notice that, in accordance with the provisions of the deed of trust executed by the Western Union Telegraph Company, under date of February 1st, 1875, to the Union Trust Company of New York, as trustee, certain bonds were drawn by lot, on the 5th inst., for redemption on the 1st day of March. The numbers, &c., can be ascertained, and the bonds will be paid at the office of Messrs. Morton, and Rose, Company, Bartholomew-lane, E.C., on and after the 1st March.

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1882.

Last week we ended our review of the year with a reference to what the Post Office has done in the way of establishing telephone exchanges. This week we may therefore fitly take up the threads of our subject by referring to private telephonic enterprise. In our review of telephonic work for 1881 we said "the progress made by the telephone during the past year has been extraordinary, and we may look for even greater advances in 1882." This forecast, which we may remark was a very safe one, has been amply verified.

The great event of the year has been what by common consent is called "The Telephone Case," though, in reality, several separate actions have been tried. The first note of battle was sounded in Edinburgh early in the year, when the United Telephone Company brought an action on the 25th of January last against an electrician named Alexander Maclean, of Edinburgh, for the infringement of Patent No. 2,909, July, 1877, taken out by Edison, and Patent No. 4,765, December, 1877, taken out by Graham Bell, through his agent, Morgan Brown. The defence was mainly that neither patents were good, as the instruments therein described had been previously made public, Edison's by Reis in 1863, and Bell's by several papers in 1876. The result of the trial was that Lord McLaren, the judge, gave judgment for the plaintiffs, and upheld the infringement of their patents. Subsequently the same company brought an action against Messrs. M. Theiler and Sons, of London, for infringing the Edison patent (this was tried on 2nd March), and a perpetual injunction was obtained.

Later on (24th April) the same company brought another action against Messrs. Harrison, Cox-Walker, and Co., of Darlington, alleging that they had made and sold three instruments which were infringements of other patents, viz., the Cox-Walker and Hickley receivers, which were said to infringe the Bell patent, and the Hunnings transmitter, which was said to infringe the Edison patent. This case was tried before Mr. Justice Fry. We need not refer here to the voluminous evidence given by electricians, from Sir William Thomson downwards, which will be found recorded in our last volume. Suffice it to say that Mr. Justice Fry decided that the defendants had infringed Bell's patent, but that Edison's patent was invalid because he had included in the provisional specification an invention, the phonograph, which was not mentioned in the complete specification, and, therefore, the plaintiffs were not entitled to an injunction as regards this patent. On May 25 the same company brought an action against Messrs. Orme and Co., of 5, Barbican, E.C., to restrain them from selling or using the Hickley telephone, and obtained an interim injunction.

In the month of June, the case of the London and Globe Telephone Company *v* the United Telephone Company came before Mr. Justice Fry. This was a motion to restrain the defendants from publishing the following notice on the cover of their subscribers' lists, viz.:—"The United Telephone Company have been advised by eminent counsel that all forms of transmitters in which carbon is used in a free or powdered form, as, for instance, in the transmitters usually known as Moseley or Hunnings, and that all the so-called microphone transmitters, including those known as the Crossley and Gower-Bell, are infringements of Mr. Edison's patent as amended by disclaimer," and a further notice to the effect that the United Company would proceed against any one making and selling such transmitters. It may be mentioned here that the London and Globe Company were assignees of the Hunnings transmitter. The result of this case was that an injunction was granted against the United Company, restraining them from issuing any such notice without a reference to Mr. Justice Fry's decision in the case of the United Telephone Company *v* Harrison, Cox-Walker, and Co., so long as that decision remained unreversed.

In the meantime the United Company had lodged a disclaimer of the phonograph, as described in Edison's provisional specification mentioned above, which was allowed by the Attorney-General and Mr. Justice Fry's decision on the patent as disclaimed was on all points in favour of the company. Four more actions were, however, brought by the United Company, one on the 25th July against Messrs. Cox and Williamson, of Plymouth, with reference to the Cox-Williamson transmitter and the Ader receiver, the result of which was in favour of the plaintiffs. Another against Mr. E. Butler, of 71, Lord-street, Liverpool, for infringing Bell's patent, on the 17th November, when the

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company obtained a perpetual injunction with costs; another against Mr. Haines, of Birmingham, for infringing both Edison's and Bell's patents, which was also tried on the 17th November, and in which the company were again successful; and yet another, against Messrs. Hebden and Co., of Bradford (Yorks.), on the 15th December, for infringing the Bell patent. In this case, also, the company obtained a perpetual injunction. So that, practically, the United Telephone Company have, after much litigation, made themselves masters of the situation for the present; and with this we will take leave of the legal vicissitudes experienced by the telephone during 1882.

There have been a great number of improvements, or so-called improvements, in telephonic apparatus patented during the year, and a few of these improved telephones have been exhibited. We are not aware, however, that they have been practically adopted to any great extent. In our 1881 review we mentioned that apparatus had been devised by means of which one line wire only would be needed for several subscribers. This apparatus was shown in the early part of the year, under the name of the inventors, Messrs. Brown and Saunders, at the Crystal Palace Exhibition, and a full description of it was given in our columns. In May, Professor Dolbear, one of our American cousins, read an interesting paper before the Society of Telegraph Engineers and of Electricians, in which he described his experiments in telephony and his new telephone receivers, which are based on the principle of induction, patents for which have recently been published. In the course of the discussion on Professor Dolbear's paper, Mr. Willoughby Smith gave some account of experiments that he had been making in the same direction, which culminated in his "inductophone," described in our issue of June 3. Mr. Smith's apparatus consisted of a large flat coil of insulated wire placed in a frame like a looking glass, and connected in circuit with a battery and a tuning fork, between the prongs of which is a small electro-magnet. The fork carries on one prong a small contact piece, which makes and breaks contact with a disc carried by a binding screw at the end of the fork. The current is arranged to have a make and break contact in the main circuit. When a current is sent through the flat coil above mentioned, lines of force radiate from it as from a short electro-magnet, and by bringing the tympanum of an ordinary Bell telephone in the field of force thus obtained, the effect was that the sound of the vibrating tuning fork was reproduced. It was noticed that the sounds could be obtained in the next room; indeed, nothing could be found through which the lines of force would not pass and and affect the telephone. We may quote here our remarks on this discovery:—"These experiments of Mr. Willoughby Smith prove that the receiving telephone may be altogether independent of the circuit of the sending instrument, so far as regards visible and material connections."

Another interesting achievement of the year was that accomplished by M. Van Rysselberghe, of the Brussels Meteorological Observatory, who succeeded in sending telegraphic and telephonic messages a considerable distance along the same line, with good results at the receiving station. This was accomplished by a method which has since been patented by the inventor, and consists briefly in interpolating a condenser in a shunt from the circuit, so that the line wire does not become suddenly, but slowly, charged; and, therefore, the induced current will be equally slow and progressive. So that instead of a series of violent and instantaneous attractions of the telephone diaphragm, produced by rapid charging and discharging of the line, we have a series of progressive and weak movements, which do not interfere with conversation, at least so the inventor claims. As the English patents relating to this invention are now published, possibly the coming year may witness some practical illustration of this principle in our own country; though, from all accounts, the telephone authorities here are not very enthusiastic about this system. During the year Captain M'Evoy has patented what has been called "a submarine detector," in which the telephone plays an important part. It consists of a box containing two coils of wire, and a make and break contact, and a telephone. From this leads a small cable containing four insulated wires, to which is attached another box containing two more coils. The four wires and the two sets of coils, &c., form two circuits, a primary and a secondary, the telephone being in the secondary circuit. A battery being connected to the primary circuit, the coils are adjusted until little or no noise from the make and break arrangement is heard in the telephone. The small box and cable is then let down into the sea or river, and on coming near to any metal body a loud noise will be heard in the telephone. As will be seen, this is simply an application of Professors Hughes and Bell's experiments to this class of work. The telephone has been tested for diving work during the year by a committee of French naval officers, with good results It has also been experimented with for the same purpose by Mr. H. H. Wake, engineer to the River Wear Commissioners, assisted by Mr. A. W. Heaviside, of the Postal Telegraph Service, at the South Dock, Sunderland, signals being exchanged between the occupant of a diving bell under water and men in a barge at the surface. Here, again, the results were satisfactory. A few experiments have been carried out on the continent, in America, and at home, with underground telephone cables, the results of which have been stated to be satisfactory. At present, however, overhead wires are the rule, and seem likely to continue so, if we may quote Mr. W. H. Preece's opinion, as given in his paper before the British Association last year. He says, "The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than 20 miles." Let us now glance at the present position of the various telephone companies, and note the progress the telephone has made in public opinion since 1881. To begin with, we may take the

United Telephone Company, of Coleman-street, E.C. This Company has been in existence for two years and three-quarters; its progress during the year will be seen at a glance from the following monthly returns of new subscribers. Thus, in January last 98 new subscribers were coupled up; in February, 93; March, 94; April, 93; May, 94; June, 113; July, 71; August, 66; September, 67; October, 87; November, 81; December, 71; or 1,028 during 1882, raising the total number of subscribers now actually connected up to 2,247. The company now has seventeen exchanges in full working order distributed throughout the metropolis. The calls, which in July last averaged about 14,000 a day, now amount to nearly 20,000, or, allowing one answer for each inquiry, 40,000 messages per day. Last year we mentioned that *The Times* utilised this company's system to verbally transmit the speeches of members of the House of Commons to its office in Printing House-square. *The Times* found the telephone so useful that it now makes use of two wires in place of the one originally employed. The *Freeman's Journal* also has adopted the same means of communication between its offices in the Strand and the House of Commons. The company hopes soon to be able to run lines between London, Liverpool, Manchester, and Birmingham. Within the last few days we chronicled the fact that they had "got through" successfully to Brighton, and that conversation had been carried on between their London and Brighton Exchanges. As a license to connect the metropolis with London-by-the-Sea has been granted by the Postmaster-

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General, we may hope shortly to hear that regular communication has been established between the two. Many newspapers are availing themselves of this company's system, and amongst them we may enumerate *The Observer* and ourselves.

In the provinces the telephone is being adopted with that leisurely appreciation of an innovation, even though pre-eminently useful, which so markedly distinguishes the stolid Briton from his more go-ahead brother in the States. In addition to its metropolitan business, the United Telephone Company has exchanges in Bristol, with 236 subscribers, and Brighton, with 58. Private telephone lines have also been erected by this company in Plymouth, Portsmouth, Southampton, and Cardiff, as well as Norwich and Ipswich, at which two latter towns exchanges are about to be opened. We also hear that the company are selling a concession to use their instruments in the south of England to a company which will be known as "The South of England Telephone Company." The chief company having exchanges in the country is the

National Telephone Company, whose head office is at 11, Queen Victoria-street, E.C. The progress made by this company during the last year or so will be readily gleaned from the following statistics, which have been supplied us by the courtesy of the company's secretary:—

Statement of Subscribers—National Telephone Co.

Stations.	Subscribers on July 31, '81.	Subscribers on July 31, '82.	Subscribers on Oct. 31, '83.
Glasgow	523	681	695
Greenock	33	63	65
Paisley	3	17	19
Dumbarton	*nil*	*nil*	*nil*
Edinburgh	171	216	224
Kirkcaldy	*nil*	7	21
Aberdeen	„	18	26
Dundee, Forfar	15	27	78
Belfast	133	207	231
Leeds	79	129	147
Bradford	67	178	201
Huddersfield	*nil*	40	46
Halifax	„	13	20
Dewsbury	„	26	45
Wakefield	„	6	6
Birmingham	71	138	145
Wolverhampton	19	31	37
Walsall	*nil*	9	26
Wednesbury	„	2	3
Dudley	„	2	2
Brierley Hill	„	2	2
Stourbridge	„	3	3
Nottingham	„	88	105

Note.—These numbers include exchange and private line subscribers.

The Oriental Telephone Company has had a somewhat exceptional experience during the year, seeing that the breaking out of war in Egypt surprised its agents in Cairo and Alexandria just as they were at their busiest. As has been recorded in these pages, however, the lines and instruments of the company proved of the greatest use to our officers, more particularly at Alexandria. It must have been as much of a surprise as a pleasure for the company to receive a letter from their agent in this town so recently as November last to the effect that telephonic communications were almost completely reinstated, and that notwithstanding the turmoil and uncertainties of war they had "virtually not lost a subscriber." The company have very recently sold their interest in Bombay and two other neighbouring Indian States to a local company known as "The Bombay Telephone Company." According to the latest figures the following represents the present *clientèle* of the company. At Alexandria they have 94 regular subscribers, 21 Government subscribers, and had, at the date of our information, applications from 17 more, or altogether 132. At Cairo they have 60 subscribers. Bombay, before the sale to the local company, contributed 81, Calcutta 108, Madras 34, Rangoon 36, Kurrachee 15, Colombo (Ceylon) 30, Singapore 70, Hong Kong 15, and Shanghai 73. At Honolulu the company have more subscribers than at any other exchange, viz., 289, which gives them a grand total of 943.

We had hoped to have given particulars relating to Messrs. Tasker, Sons, and Co.'s exchange at Sheffield, and the Lancashire and Cheshire Company's exchanges at Liverpool, Manchester, and elsewhere, but have not yet received the necessary information.

THE LATE MR. C. V. WALKER.

The death of this well-known practical electrician, which we announced in our last issue, and which took place on Christmas eve, will recall to many minds the early days of telegraphy and the struggles it had to engage in before it became the indispensable servant of the public. Mr. C. V. Walker's name is intimately associated with those struggles, and although he was never in the foremost rank of promoters or inventors, his active and intelligent assistance to the cause of telegraphic enterprise at the most trying period of its history will ever entitle him to an honourable place by the side of the great pioneers. For nearly forty years, and down to the time of his decease, Mr. Walker had been in the service of the South Eastern Railway Company, for the greater part of the time as their manager of the telegraphs. It was on this line that he assisted Mr. Cooke in erecting its first telegraph wire, and ever since then his labours have been unceasing in maintaining and perfecting the vast and important system of wires which have grown upon that line of railway. Railway telegraph signalling was of course his chief care, the block system by means of electric bells having been first introduced by him on this line, to be superseded by visual signals later on, in 1863-4. Many years previously Mr. Walker had used gutta percha covered wire for underground telegraph wires and for wires carried through tunnels. The credit of being the first to use gutta percha insulated wire for such purposes, we believe, belongs to him. This was in 1847. The following year an experiment of far greater import was successfully carried out under his direction. He was the first to perform the feat of laying a telegraph cable. From a ship stationed a couple of miles or so off Folkestone Mr. Walker signalled a message to London, the cable from the ship being joined to the land lines on Folkestone beach. This took place on October 13, 1848, which is a day deserving of being remembered, especially in connection with the veteran electrician who has now gone from among us. Several valuable inventions, or rather, we should say devices, connected with train signalling are due to Mr. Walker, among which we may mention the single stroke bell and compound key (1851); a galvanometer-semaphore (1854); a single wire electro-magnetic telegraph semaphore (1863); and various contrivances for putting passengers and guards in electrical communication with each other, some of which are as recent as 1875.

Many years before, associating himself with the erection and maintenance of telegraphs, Mr. Walker had taken an active part in the proceedings of the London Electrical Society, so much so that in 1843 he became its secretary. Prior to the formation of the *Electrical Magazine* in that year, however, Mr. Walker had shown his taste for literary work by the publication of a manual of electrotyping which has since, we believe, run through as many editions as any of our most popular novels. Mr. Walker's name was also associated with Dr. Lardner's in the literary scheme for popularising scientific subjects. In the year 1853 De La Rive's celebrated "Treatise on Electricity in Theory and Practice" was introduced to English readers by a translation of Mr. Walker's, and soon after its appearance, namely, in 1855, he was elected a Fellow of the Royal Society.

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Several original papers from the same pen appear in the *Proceedings* of the Royal Society and *Phil. Trans.* between the year just named and 1862, chiefly relating to magnetic storm phenomena and meteorology—subjects in which the deceased gentleman always took the greatest interest. In this connection it may be mentioned that the situation of the lines over which he had control brought him into relation with the chiefs of the Greenwich Observatory, and on all occasions he was ready to render them the greatest assistance in the matter of earth currents, magnetic storms, and the telegraphing of Greenwich time signals. Indeed, the first introduction of these latter seems to have originated with Mr. Walker and the late Astronomer-Royal, Sir G. B. Airy, some thirty years ago.

With the objects and formation of the Society of Telegraph Engineers Mr. Walker took a lively interest for many years, and in 1876 was elected its president. The address which he delivered on that occasion was published at length in the *Journal* of the Society, and will well repay perusal even now. Mr. Walker attained the full age allotted to man, having died in his 71st year.

CORRESPONDENCE.

STATIC ELECTRICITY AND QUANTITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Sprague's letter on page 186, I will first remark on his statements about quantity of force, as I am in hopes that it may lead to a comprehension on my part of what Mr. Sprague means by the word quantity, for it certainly appears to me at present that he does not use the term in its ordinary sense.

Newton says, Definition IV., "Vis impressa est actio in corpus exercita, ad mutandum ejus statum vel quiescendi vel movendi uniformiter in directum." This definition does not imply that force is something having a separate existence, and this was very clearly put by the late Professor Clifford when he described force as the change of momentum of a body considered as depending upon its position relative to other bodies. Now, it is convenient to be able to express this idea in a single word in place of always using a long expression, and hence the utility of the word force. Having, however, once introduced the word, we see that it is something which has both magnitude and direction, and therefore we say that a force is a quantity having direction.

I made use of the idea of force merely to point out that the idea of magnitude, or quantity, may be associated with what is admittedly not a thing having a separate existence of its own, but I do not, therefore, either affirm or deny that electricity has such a separate existence, as we are as yet entirely ignorant of its nature.

Now, Faraday's ice-pail experiments show that two or more electrifications can be combined experimentally with a result of the same kind as when two quantities are added algebraically. "We are, therefore," says Maxwell, "entitled to use language fitted to deal with electrification as a quantity as well as a quality, and to speak of any electrified body as charged with a certain quantity of positive or negative electricity." Maxwell, at the same time, cautions us against too hastily placing electricity in any known category of physical quantities, since all that the ice-pail experiments prove is that electricity cannot be created or annihilated, so that, if the total quantity of electricity within a closed surface be altered, the increase or diminution must have passed through the surface.

One expression of Mr. Sprague's is completely incomprehensible to me, viz., that in which he says that attraction and pressure "cannot be expressed as quantities but as degrees."

By a quantity is meant something which can be either greater or less or equal to something else of a similar kind. What else does Mr. Sprague mean when he speaks of degrees?

It appears from Mr. Sprague's letter that I have misunderstood him in supposing him to hold that electricity is a form of energy, but as he denies this I am unable to understand the table which he gives on page 129 of this volume. Mr. Sprague's statement on page 151 of Vol. IV., "I hold that electricity has no actual existence, that it is not an element, nor a fluid; that it is not a force, but that it is like heat, simple energy—energy distributed upon chains of material molecules," &c., also seems to me quite irreconcileable with his present statement that he does not hold electricity to be a form of energy. With the latter statement before me I should have refrained from the above quotation, supposing simply that Mr. Sprague had changed his opinion, had it not appeared to me practically identical with the statement made in the table which I have alluded to.

Mr. Sprague now says that he considers electricity to be the square root of energy.

Now, quantity of electricity Q, is of the dimensions $L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-1}$ in the electrostatic system, and $L^{\frac{1}{2}} M^{\frac{1}{2}}$ in the electromagnetic system, L, M, T, representing the units of length, mass, and time respectively; again, electromotive force E, is of the dimensions $L^{\frac{1}{2}} M^{\frac{1}{2}} T^{-1}$ in the electrostatic system, and $L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-2}$ in the electro-magnetic. But, as I pointed out in my letter on page 162, E Q is an expression for energy, and therefore if Q^2 were also an expression of energy, as Mr. Sprague asserts, it would be necessary that E and Q should be of equal dimensions in the fundamental units, which, however, is not the case.—Yours, &c.,

G. W. von TUNZELMANN.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am sorry I have not been able to reply to your other correspondents at an earlier date on account of pressure of business, but will now take advantage of your kindness.

In reference to "Loose Contact's" letter in your issue of December 23, in his desire to indulge in invective I am afraid he has run away with himself, and asserts that I am wrong, but fails to point where, no doubt an oversight, or his failing to see the argument is possibly my fault through want of lucidity in writing, which I will now endeavour to make clear.

With a platinum and carbon contact an increase of current takes place in the primary circuit on a pressure greater than the normal being applied to the diaphragm. The resistance of the circuit being diminished, a corresponding diminution of current takes place when the pressure is removed.

This current wave will cause induced currents to flow in the transmitter secondary, which simple fact is I think well enough known. Therefore, microphonic action will take place independent of an intermittent contact with or without matter filling the gaps.

With this in view it is clear it is not necessary that an open contact should exist to produce microphonic action, *i.e.*, induced currents in the secondary through variation of current in the primary, and by the experiment I endeavoured to show that a single thrust and recovery given to the diaphragm produces this effect, with which it was impossible any open contact could exist. All that remains, then, is to consider whether an intermittent contact can possibly exist. One little circumstance I omitted to mention in my last letter, and to which I would direct Mr. Rathbone's attention, is that if the carbon be drawn away from the diaphragm the platinum stud *will follow* the carbon button through the space of a quarter of an inch or more before it breaks circuit. This is a small matter, but its importance is obvious, and the effect of this action being prevented by the platinum stud sticking to the diaphragm by rust is I presume perfectly well known to "Loose Contact," who, I have no doubt (judging from the tone of his letter), has a practical acquaintance with the instrument. In consideration of the above and the parti-

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culars of the construction of this transmitter given in my last, I hold that the existence of an intermittent contact is a mechanical impossibility when spoken into in a colloquial tone. All sound waves striking the diaphragm force it inwards, thereby increasing the normal pressure.

Regarding his suggested experiment with a metallic body supplanting the carbon, I would feel inclined to ask if "Loose Contact" has tried it? I have, and, after *very careful* adjustment of the transmitter, got it to speak, but that was all. It was of the faintest possible description, and might be safely considered a practical failure, the trial being made under precisely similar conditions. I enclose the brass button for your inspection.

Now, according to "Loose Contact's" letter, I should have precisely the same result as if carbon had been employed. How was it different? Unless from the fact that the carbon possesses a property which is foreign to the brass. Perhaps he can explain.

Further, I connected it up with the "bridge," and found the resistance to be ·9 ohm (with the carbon it was 4·8 ohms), and "tickled" it with a bristle, but the needle of the galvanometer did not respond, as when the carbon was used. How is this to be explained? Would it not be fair to assume that the brass had reached its maximum conductivity?

These results are disappointing after reading "Loose Contact's" letter.

The carbon spoke as only carbon can, and if "Loose Contact" has any other substance, compound or elementary, that will do the work as well, I will be very happy to give it a trial.

I would here take the liberty of reminding "Loose Contact" that contradictory assertion without proof is of little value in a discussion of this nature, and that seeing my letter, which you have kindly given space to, bears my signature, I think "Loose Contact," in common courtesy, should also sign his name, and until such time as he finds it convenient to do so I must decline to take further notice of his contributions.

In the same issue I observe a letter from Mr. Berliner, in which he suggests an air film as the cause of microphonic action. In the case of the platinum point bearing against the carbon, I can hardly conceive two *bodies in contact*, and a *third one between them*. I think the admission of a possible air space would be extremely favourable to the "arc" theory. Would not Mr. Berliner think the diminution of resistance of the transmitter in vacuo to be due to the extraction of air from the pores of the carbon itself, rather than to the exhaustion of the surrounding atmosphere, the rounded platinum point being *in contact* with the carbon, which it decidedly is when properly adjusted. The effect I fancy is somewhat akin to that which takes place in a vacuum tube.—Yours, &c.,

R. D. SMILLIE, Electrician.

National Telephone Company (Limited), Glasgow.

January 10, 1883.

"GLOW" LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have to thank Mr. Preece for calling my attention to the definition of "glow" given in the "Imperial Dictionary." It is, "to shine with intense heat, or, perhaps more correctly, to shine with a white heat, to exhibit incandescence, hence, in a more general sense, to shine with a bright lustre." Mr. Preece then asks if this is not exactly applicable to the carbon filament in a Swan lamp when heated by the current. I frankly admit that it is; but then it is also applicable to much more. It is equally applicable to the arc lamp, and will even take in a gas flame. My objection to the term "glow" is that it has too wide a meaning in the English language. The German verb *glühen* has, I believe, a more restricted sense, and, primarily, means to make red hot. But our word glow has come to have a most elastic signification, far more elastic even than the above dictionary definition. In the general sense of the people, and this after all is the truest test, it means, on the one hand, a luminous effect *similar* to that given by incandescence but not necessarily due to incandescence, and on the other a sensation like that due to warmth. The same dictionary speaks of a face "glowing" with blushes, a person glowing with animation, and so on. A word which includes the spark of a glowworm, or the gleam of a firefly, the reflection of sunlight on snow, the intense lustre of the voltaic arc, and a feeling of warmth, is surely discredited as a distinctive term for the incandescence lamp. What, for example, should we do if another electric lamp were invented which "glowed" equally well by some other means than incandescence?

It is, of course, much easier to find fault than to do better. But I think the lamp should be named, not from its *appearance*, but from some essential property or peculiar feature of its action. If "incandescence" is too long (and though longish it is really not difficult to pronounce and not ineuphonious) we have the term "filament" lamp, and a still shorter term would be "loop" lamp. Incandescence might remain the generic name.—Yours, &c.,

J. MUNRO.

MR. ELLIS LEVER'S PREMIUM FOR MINING LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you or any of your readers kindly give me particulars (or state where they may be obtained) of requirements of the mining lamps for which Ellis Lever, Esq., M.P., has offered a premium of £250?—Yours, &c.,

INVENTOR.

CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture I. (concluded)—The Dynamo in Theory.

(CONTINUED FROM PAGE 190.)

Field-magnets.

The coils of the field-magnets of a dynamo cannot be constructed of no resistance. They, therefore, always waste some of the energy of the currents in heat. It has, therefore, been argued that it cannot be economical to use electro-magnets in comparison with permanent magnets of steel, which have only to be magnetised once for all. Nevertheless, there are certain considerations which tell in favour of electro-magnets. For equal power, their prime cost is less than that of steel magnets, which, moreover, are not permanent, but require remagnetising at intervals. Moreover, as we have seen, from the fact that there is a limiting velocity at which it is safe to run a machine, it is important, in order not to have machines of needlessly great size, to use the most powerful field-magnets possible. But if we do not get our magnetism for nothing, and find it more convenient to spend part of our current upon the electro-magnets, economy dictates that we should so construct them that their magnetism may cost us as little as possible. To magnetise a piece of iron requires the expenditure of energy; but when once it is magnetised, it requires no further expenditure of energy (save the slight loss by heating in the coils, which may be reduced by making the resistance of the coils as little as possible) to keep it so magnetised, provided the magnet is doing no work. Even if it be doing no work, if the current flowing round it be not steady, there will be loss. If it do work, say, in attracting a piece of iron to it, then there is an immediate and corresponding call upon the strength of the current in the coils, to provide the needful energy. This point may be illustrated by the following experiment:—Let a current from a steady source (see Fig. 10) pass through an incandescent lamp, and also through an electro-magnet, whose cores it magnetises. When once established, the current is perfectly steady, and none of its energy is wasted on the magnet (save the negligible trifle due to the resistance of the coils). But if now the magnet is allowed to do work in attracting an iron bar toward itself, the light of the lamp is seen momentarily to fade. When the iron bar is snatched away, the light exhibits a momentary increase; in each case resuming its original intensity when the motion ceases. Now, in a dynamo where, in many cases, there

* Reprinted from the *Journal of the Society of Arts*.

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are revolving parts containing iron, it is of importance that the approach of a recession of the iron parts should not produce such reactions as these in the magnetism of the magnet. Large, slow-acting field-magnets are therefore advisable. The following points embody the conditions for attaining the end desired.

(*a.*) The body of the field-magnets should be solid. Even in the iron itself currents are induced, and circulate round and round whenever the strength of the magnetism is altered. These self-induced currents tend to retard all changes in the degree of magnetisation. They are stronger in proportion to the square of the diameter of the magnet, if cylindrical, or to its area of cross-section. A thick magnet will, therefore, be a slow-acting one, and will steady the current induced in its field.

(*b.*) Use magnets having in them plenty of iron. It is important to have a sufficient mass, that saturation may not be too soon attained.

(*c.*) Use the softest possible iron for field-magnets, not because soft iron magnetises and demagnetises quicker than other iron (that is here no advantage); but because soft iron has a higher magnetic susceptibility than other iron—is not so soon saturated.

(*d.*) Use long magnets. Again, the use of long magnets is to steady the magnetism, and, therefore, to steady the current. A long magnet takes a longer time than a short magnet to magnetise and demagnetise. It costs more than a short magnet, it is true, and requires more copper wire in the exterior coil; but the copper wire may be made thicker in proportion, and will offer less resistance. The magnetism so obtained should be utilised as directly as possible, therefore

(*e.*) Place the field-magnets or their pole-pieces as close to the rotating armature as is compatible with safety in running.

(*f.*) Avoid edges and corners on the magnets and pole-pieces if you want a uniform field. The laws of distribution of the mag-

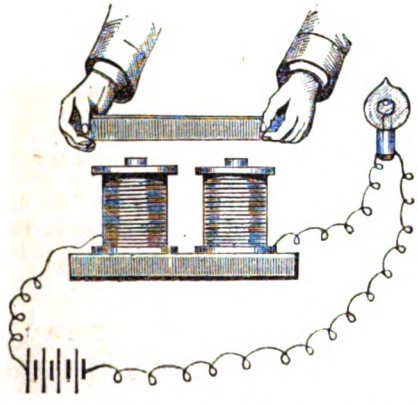

FIG. 10.—Reaction of Moving Mass of Iron on an Electro-Magnet.

netic lines of force round a pole are strikingly akin to those of the distribution of electrification over a conductor. We avoid edges and points in the latter case, and ought to do in the former. If the field-magnets or their pole-pieces have sharp edges, the field cannot be uniform, and some of the lines of force will run uselessly through the space outside the armature instead of going through it. Theoretically, the very best form to give externally to a magnet is that of the curves of the magnetic lines of force.

(*g.*) Reinforce the magnetic field by placing iron, or, better still, electro-magnets, within the rotating armature. In many cases this is done by giving the armature coils iron cores which rotate with them; in other cases, the iron cores of internal masses are stationary. In the former case there is loss by heating; in the latter, there are structural difficulties to be overcome. Siemens has employed a stationary mass within his rotating drum-armature. Internal electro-magnets serving the function of concentrating the magnetism of the field, and of so providing a continuous magnetic circuit, have been used by Lord Elphinstone and Mr. Vincent. A similar device obtains in Sir W. Thomson's "mouse-mill" dynamo, and in Jürgensen's dynamo.

(*h.*) In cases where a uniform magnetic field is not desired, but where, as in dynamos of the second class, the field must have varying intensity at different points, it may be advisable specially to use field-magnets with edges or points, so as to concentrate the field at certain regions.

Pole-pieces.

(*i.*) The pole-pieces should be heavy, with plenty of iron in them, for reasons similar to those urged above.

(*j.*) The pole-pieces should be of shapes really adapted to their functions. If intended to form a single approximately uniform field, they should not extend too far on each side. The distribution of the electromotive force in the various sections of the coils on the armature depends very greatly on the shape of the pole-pieces.

(*k.*) Pole-pieces should be constructed so as to avoid, if possible, the generation in them of useless Foucault currents. The only way of diminishing loss from this source is to construct them of laminæ, built up so that the mass of iron is divided by planes in a direction perpendicular to the direction of the currents, or of the electromotive forces tending to start such currents.

(*l.*) If the bed-plates of dynamos are of cast iron, care should be taken that these bed-plates do not short-circuit the magnetic lines of force from pole to pole of the field-magnets. Masses of brass, zinc, or other non-magnetic metal may be interposed; but are at best a poor resource. In a well-designed dynamo there should be no need of such devices.

Field-magnet Coils.

(*m.*) In order to be of the greatest possible service, the coils of the field-magnets should be wound on most thickly at the middle of the magnet, not distributed uniformly along its length, nor yet crowded about its poles. The reason for this is two-fold. Inspection of Fig. 6 will show that many of the lines of force of a magnet "leak out" from the sides of the magnet before reaching its poles, where they should all emerge if the mass of the magnet were perfectly equally magnetised throughout its whole length. Internally, the magnetisation of the magnet is greatest at its centre. At, or near the centre, therefore, place the magetising coils, that the lines of force due to them may run through as much iron as possible. The second reason for not placing the coils at the end is this—any external influence which may disturb the magnetism of a magnet, or affect the distribution of its lines of force, affects the lines of force in the neighbourhood of the pole far more than those in any other region. It is for this reason that in Bell's telephones, where it is desired to make a magnet most sensitive to variations in intensity, the coils are fixed on at the pole. In the field-magnet of a dynamo, on the contrary, where the magnet is wanted to be as steady and as constant as possible in its magnetic power, the coils should not be placed on the poles.

(*n*) The proper resistances to give to the field-magnet coils of dynamos have been calculated by Sir William Thomson,* who has given the following results:—

For "Series Dynamo," make the resistance of the field-magnets a little less than that of the armature. Both of them should be small, compared with the resistance of the external circuit. The ratio of the waste by heating in the machine, to the total electric work of the machine, will be—

$$\frac{\text{waste}}{\text{total work}} = \frac{R_M + R_A}{R_M + R_A + R_X}$$

$$\text{and } \frac{\text{useful work}}{\text{total work}} = \frac{R_X}{R_M + R_A + R_X}$$

where R_M is the resistance of the magnets,

R_A „ „ of the armature,

R_X „ „ of the external circuit.

For a "Shunt Dynamo," the rule is different. The best proportions are when such that

$$R_X = \sqrt{R_M R_A} \text{ or that}$$

$$R_M = \frac{R_X^2}{R_A}$$

also the ratio of useful work is:—

$$\frac{\text{useful work}}{\text{total work}} = \frac{1}{1 + 2\sqrt{\frac{R_A}{R_M}}}$$

An example of the latter may be of advantage. Suppose it was wished that the waste should not be more than 10 per cent. of the useful work, the ratio of the formula must equal $\frac{10}{11}$, or $1 \div 1\frac{1}{10}$. Hence $\sqrt{\frac{R_A}{R_M}}$ must equal $\frac{1}{20}$; or R_M the resistance of the field-magnets must be 400 times R_A that of the armature.

Armature Cores.

(*o*) Theory dictates that if iron is employed in armatures, it must be slit or laminated, so as to prevent the generation o

* British Association Report, 1881, p. 528.

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Foucault currents. Such iron cores should be structurally divided in planes normal to the circuits round which electromotive force is induced; or should be divided in planes parallel to the lines of force and to the direction of the motion. Cores built up of varnished iron wire, or of thin discs of sheet iron separated by varnish, asbestos paper, or mica, partially realise the required condition.

(*p.*) Armature cores should be so arranged that the direction of polarity of their magnetisation is never abruptly reversed during their rotation. If this precaution is neglected the cores will be heated.

Armature Coils.

(*q.*) All needless resistance should be avoided in armature coils, as hurtful to the efficiency of the machine. The wires should, therefore, be as short and as thick as is consistent with obtaining the requisite electromotive force, without requiring an undue speed of driving.

(*r.*) The wire should be of the very best electric conductivity. The conductivity of good copper is so nearly equal to that of silver (over 96 per cent.), that it is not worth while to use silver wires in the armature coils of dynamos.

(*s.*) In cases where rods or strips of copper are used instead of mere wires, care must be taken to avoid Foucault currents by laminating such conductors, or slitting them in planes parallel to the electromotive force, that is to say, in planes perpendicular to the lines of force, and to the direction of the rotation.*

(*t.*) In dynamos of the first class, when used to generate currents in one direction, since the currents generated in the coils are doing half their motion inverse to those generated during the other half of their motion, a commutator or a collector of some kind must be used. In any single coil without a commutator, the alternate currents would be generated in successive revolutions, if the coil were destitute of self-induction currents, whose variations may be graphically expressed by a recurring sinusoidal

Fig. 11.

curve, such as Fig. 11. But if by the addition of a simple split-tube commutator the alternate halves of these currents are reversed, so as to rectify their direction through the rest of the circuit, the resultant currents will not be continuous, but will be of one sign only, as shown in Fig. 12, there being two currents

Fig. 12.

generated during each revolution of the coil. If two coils are used, at right-angles to each others' planes, so that one comes into the position of best action, while the other is in the position of least action (one being normal to the lines of force, when the other is parallel to them), and their actions be superposed, the result will be, as shown in Fig. 13, to give a current

Fig. 13.

which is continuous, but not steady, having four slight undulations per revolution. If any number of separate coils are used, and their effects, occurring at regular intervals, be superposed, a similar curve will be obtained, but with summits proportionately more numerous and less elevated. When the number of coils used is very great, and the overlappings of the curves still more complete, the row of summits will form practically a straight line, or the whole current will be practically constant.

(*u.*) The rotating armature coils ought, therefore, to be divided into a large number of sections, each coming in regular succession into the position of best action.

(*v.*) If these sections or coils are independent of each other, each coil, or diametral pair of coils, must have its own commutator. If they are not independent, but are wound on in continuous connection all round the armature, a collector is needed, consisting of parallel metallic bars as numerous as the sections, each bar communicating with the end of one section and the beginning of the next.

(*w.*) In any case, the connections of such sections and of the commutators, or collectors, should be symmetrical round the axis; for if not symmetrical, the induction will be unequal in the parts that successively occupy the same positions with respect to the field-magnets, giving rise to inequalities in the electromotive force, sparking at the commutator, or collector, and other irregularities.

(*x.*) In the case where the coils are working in series, it is advantageous to arrange the commutator to cut out the coil that is in the position of least action, as the circuit is thereby relieved of the resistance of an idle coil. But no such coil should be short-circuited to cut it out. In the case where the coils are working in parallel, cutting out an idle coil increases the resistance, but may be advisable to prevent heating from waste currents traversing it from the active coils.

(*y.*) In the case of pole-armatures, the coils should be wound on the poles rather than on the middles of the projecting cores; since the variations in the induced magnetism are most effective at or near the poles. (See § *m.*)

(*z.*) Since it is impossible to reduce the resistance of the armature coils to zero, it is impossible to prevent heat being developed in those coils during their rotation; hence it is advisable that the coils should be wound with air spaces in some way between them, that they may be cooled by ventilation.

(*aa.*) The insulation of the armature coils should be ensured with particular care, and should be carried out as far as possible with mica and asbestos, or other materials not liable to be melted, if the armature coils become heated.

Commutators, Collectors, and Brushes.

(*ab.*) Commutators and collectors being liable to be heated through imperfect contact, and liable to be corroded by sparking, should be made of very substantial pieces of copper.

(*ac.*) In the case of a collector made of parallel bars of copper, ranged upon the periphery of a cylinder, the separate bars should be capable of being removable singly, to admit of repairs and examination.

(*ad.*) The brushes should touch the commutator or the collector at the two points, the potentials of which are respectively the highest and the lowest of all the circumference. In a properly and symmetrically built dynamo, these points will be at opposite ends of a diameter.

(*ae.*) In consequence of the armature itself, when traversed by the currents, acting as a magnet, the magnetic lines of force of the field will not run straight across, from pole to pole, of the field-magnets, but will take, on the whole, an angular position, being twisted a considerable number of degrees in the direction of the rotation. Hence the diameter of commutation (which is at right angles to the resultant lines of force in machines of the Siemens and Gramme type, and parallel to the resultant lines of force in machines of the Brush type) will be shifted forward. In other words, the brushes will have a certain angular lead. The amount of this lead depends upon the relation between the intensity of the magnetic field and the strength of the current in the armature. This relation varies in the four different types of field-magnets. In the series dynamo, where the one depends directly on the other, the angle of lead is nearly constant, whatever the external resistance. In other forms of dynamo the lead will not be the same, because the variations of resistance in the external circuit do not produce a proportionate variation between the two variables which determine the angle of lead.

(*af.*) Hence in all dynamos it is advisable to have an adjustment, enabling the brushes to be rotated round the commutator or collector, to the position of the diameter of commutation for the time being. Otherwise there will be sparking at the brushes, and in part of the coils at least the current will be wasting itself by running against an opposing electromotive force.

(*ag.*) The arrangements of the collector, or commutator, should be such that, as the brushes slip from one part to the next, no coil or section in which there is an electromotive force should be short circuited, otherwise work will be lost in heating that coil. For this reason, it is well so to arrange the pole pieces that the several sections or coils on either side of the neutral position should differ but very slightly in potential from one another.

(*ah.*) The number of contact points between the brushes and the collector, or commutator, should be as numerous as possible, for by increasing the number of contacts, the energy wasted in sparks will be diminished inversely as the square of that number. The brushes might, with advantage, be laminated, or made of parallel loose strips of copper, each bearing edgeways on the collector.

Relation of Size to Efficiency.

The efficiency of a dynamo-electric machine is the ratio of the

*It will be observed that the rule for eliminating Foucault currents is different in the three cases, for magnets and their pole-pieces, for moving iron armature cores, and for moving conductors in the armature.

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useful electrical work done by the machine to the total mechanical work applied in driving it. Every circumstance which contributes to wasting the energy of the current reduces the efficiency of the machine. In the preceding paragraphs it has been shown what the chief electric sources of waste are, and how they may be avoided. The precautions needful to obviate Foucault currents, to avoid reversals of magnetisation, to get rid of needless resistance, to obviate opposing electromotive forces, have been detailed. Mechanical friction of the moving parts can be minimised also by due mechanical arrangements. But one thing cannot be entirely obviated, because even the best conductors employed have a certain resistance. We cannot prevent the heating of the conducting coils; and the more powerful the current generated by the machine the more important does this source of waste become. There is but one way to reduce this, and that is by increasing the size of the machines. For some three years or so I have been the advocate of large dynamo machines, not because I have any admiration for mere bigness, but because, as in steam-engines so in dynamos, the larger machines may be made more efficient than the small, in proportion to their cost. In discussing the relation of size to efficiency, I shall assume, for the sake of argument, that the size of any machine can be increased n times in every dimension, and that though the dimensions are increased, the velocity of rotation remains the same, and that the intensity of the magnetic field, per square centimetre, remains also constant. If the linear dimensions be n times as great in the larger machine as in the smaller, the area it stands on will be increased n^2 times, and its volume and weight n^3 times. The cost will be less than n^3 times but greater than n times. If the same increase of dimensions in the coils be observed (the number of layers and of turns remaining the same as before), there will be in the armature coils a length n times as great, and the area of cross-section of the wire will be n^2 times as great as before. The resistance of these coils will, therefore, be but $\frac{1}{n}$ part of the original resistance of the smaller machine. If the field-magnet coils are increased similarly they will offer only $\frac{1}{n}$ of the resistance of those of the smaller machine. Moreover, seeing that while the speed of the machine is the same, the area cut through by the rotating coils is increased n^2 times, these coils will in the same time cut n^2 times as many lines of force, or the electromotive force will be increased n^2 times. Supposing the whole of the circuit to be similarly magnified, its resistance will also be but $\frac{1}{n}$ of the previous value.

If the machine is a "series"-wound dynamo, an electromotive force n^2, working through $\frac{1}{n}$ resistance, will give a current n^3 times as great as before. Such a current will, as a matter of fact, much more than suffice to bring up the magnetic field to the required strength, viz., n^2 times the area of surface magnetised to the same average intensity per square centimetre, as stipulated; for the mass of iron being n^3 times as great, it need not be so much saturated as before to give the required field. Here an economy may be effected, therefore, by further reducing the number of coils, and, therefore, the wasteful resistance of the field magnet coils, in the proportion of n^3 to n^2, or to $\frac{1}{n}$ of its already diminished value. Even if this were not done, by the formula given above for the electrical efficiency of a "series" dynamo, the waste, when working through a constant external resistance, will be n-fold less than with the smaller machine. Now, if the current be increased n^3 times, and the electromotive force n^2 times, the total electric work which is the product of these will be n^5 times greater than in the small machine, and it will consume n^5 times as much power to drive it.* It is clearly an important economy, if a machine costing less than n^3 times as much, will do n^5 as much work (to say nothing of the increased ratio of efficiency). A machine doubled in all its linear dimensions will not cost eight times as much, and will be electrically thirty-two times as powerful a machine.

Suppose the machine to be "shunt" wound, then to produce the field of force of n^2 times as many square centimetres area, will require (if the electromotive force be n^2 times as great) that the absolute strength of the current remain the same as before in the field-magnet coils. This can be done by using the same sized wire as before, and increasing its length n^2 times, to allow for n times as many turns, of n times as great a diameter each, in the same number of layers of coils as before. In this case the work done in the shunt being equal to the product of the n^2-fold electromotive force into the unaltered current will be only n^2 times as great, while the whole work of the machine is augmented n^5 times. Now, if while augmenting the total work n^5 times, we have increased the waste work not to n^5 times, but only n^2 times, it is clear that the ratio of waste to the total effect is diminished n^3-fold. There is, therefore, every reason to construct large machines, from the advantage of economy, both in relative prime cost and relative efficiency.

Being desirous of testing the correctness of the deduction that the working capacity of a machine of n-fold linear dimensions is n^5 times as great, I constructed a little instrument, of which a drawing is given in Fig. 14. In this instrument there are two

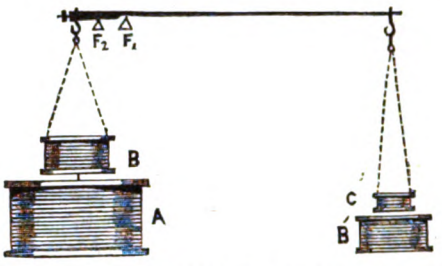

FIG. 14.—S. P. Thompson's Experimental Balance.

pairs of coils, that on the left being in every way the counterpart of that on the right, but of double linear dimensions. When all four coils were traversed by the same current, the point of equilibrium was $\frac{1}{17}$ of the length of the beam from the extremity; or the attraction of the larger system was sixteen times that of the smaller. Now, it is clear that the larger force can be exerted through double the distance, or that the work-power is 32-fold, and 32 is 2^5, as theory requires. After I had constructed my apparatus I learned that M. Marcel Deprez had made a very similar arrangement, but without the beam, to prove that the statical forces of similar machines are (see foot-note *ante*) proportional to the fourth power of the linear dimensions. M. Deprez's instrument consisted of a modified Mascart's electro-dynamometer, having a coil suspended from a balance, and acted upon by two others, placed axially above and below it (see Fig. 15). The force was measured by directly balancing it against weights. Two such arrangements were made, one double the size of the other, and when equal currents were sent through them M. Deprez found the forces to be as 5·600 to 0·355 kilos., or almost exactly 16 to 1.

Methods of Exciting the Field Magnetism.

It only remains to develop certain theoretical considerations respecting the method of exciting the magnetism of the field, in which the armatures are to revolve. The four main methods have already been alluded to at the outset of this lecture; but nothing has been said about the advantages or disadvantages of the four systems.

Magneto-Dynamos.—The magneto-dynamos (Fig. 4) have the

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* This calculation agrees with the result deduced on entirely different principles by M. Marcel Deprez. M. Deprez considers the mutual reaction, dF, between two elements, ds and ds', of a system of conductors which, by Ampère's principle, is

$$dF = C^2 \frac{ds\, ds'}{r^2} f(a),$$

where C is the current, r the distance of the elements apart, and $f(a)$ a certain function of the machine, independent of its size. Writing a' for the area, we have

$$dF = \frac{C^2}{a^2} \cdot \frac{ads \cdot ads'}{r^2} \cdot f(a)$$
$$= \frac{C^2}{a^2} \cdot \frac{dv \cdot dv'}{r^2} \cdot f(a),$$

which, if the linear dimensions be increased n times, becomes

$$dF' = \frac{C^2}{a^2} \cdot \frac{n^3 dv \cdot n^3 dv'}{n^2 r^2} \cdot f(a)$$
$$= n^4 dF,$$

whence, since this is true for all elements of the circuits, $\frac{F'}{F} = n^4$, which is Deprez's so-called "law of similars," which asserts that for similar machines the "statical effort" increases as the fourth power of the linear dimensions. But work W = F × distance, and, in the similar machine whose dimensions are increased n times, the available distance through which the force F′ can act is also n times greater. Hence, $\frac{W'}{W} = n^5$, as above.

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advantage, in theory at least, that their electromotive force is very nearly exactly proportional to the velocity of rotation; though, of course, the variable difference of potential between the terminals of the circuit will depend on the relation of the resistance of the external circuit to the internal resistance of the armature coils. They possess the disadvantage that, since steel cannot be permanently magnetised to the same degree as that which soft iron can temporarily attain, they are not so powerful as other dynamos of equal size.

Separately-excited Dynamos.—The separately-excited dynamo (Fig. 3) has the same advantage as the magneto-machine, in electromotive force being independent of its accidental changes of resistance in the working circuit, but is more powerful. It has, moreover, the further advantage that the strength of the field is under control. For by varying either the electromotive force or the resistance in the exciting circuit, the strength of the magnetic field is varied at will. It has the disadvantage of requiring a separate exciting machine.

Series Dynamos.—The ordinary, or series dynamo (Fig. 1), is usually a cheaper machine, for equal power, than any of the other forms, as its coils are simpler to make than those of a shunt machine, and it wants no auxiliary exciter. It has the disadvantages of not starting action until a certain speed has been attained, or unless the resistance of the circuit is below a certain minimum. It is also liable to become reversed in polarity, a serious disadvantage when this machine is applied for electroplating, or for charging accumulators.

From its arrangements, it is clear that any increase of resistance in the circuit lessens its power by diminishing the strength of its magnetic field. Hence it is better adapted for use with lamps arranged in parallel arc than for lamps arranged in series.

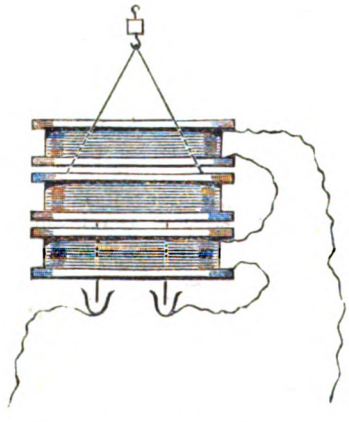

FIG. 15.—Marcel Deprez's Electro-dynamic Balance.

An additional lamp switched in, in series, adds to the resistance of the circuit, and diminishes the power of the machine to supply current. While, on the other hand, an additional lamp in parallel reduces the total resistance offered by the network of the circuit, and adds to the power of the machine to provide the needed current. It is easy to regulate the currents given by a series dynamo, by introducing a shunt of variable resistance across the field-magnet, thus altering the magnetising influence of the current.

Shunt Dynamos.—The shunt dynamo (Fig. 2), has several advantages over other forms. It is less liable to reverse its polarity than the series dynamo, and it is commonly considered as providing the magnetising power to the magnets with less waste of current. Moreover, for a set of lamps in series, its power to supply the needful current increases with the demands of the circuit, since any added resistance sends additional current round the shunt in which the field-magnets are placed, and so makes the magnetic field more intense. On the other hand, there is a greater sensitiveness to inequalities of driving in consequence of the great self-induction in the shunt. As previously pointed out, when there are sudden changes in the electromotive force acting in a complex circuit, the momentary currents thus set up do not distribute themselves in the various parts of the circuit in the simple inverse ratio of the resistances, for their distribution depends also, and in some cases chiefly, upon the self-induction in the various parts. It is more difficult to set up a sudden current in a circuit whose self-induction is great (or which, for example, consists of many turns wound closely together, so that they exercise great inductive action on each other, especially if they be wound about an iron core) than in one in which the self-induction is small. We cannot here follow further the mathematical law of the action of self-induction on momentary changes of electromotive force. But the application to the shunt-wound dynamo is too important to be passed over.

Any of these systems may be applied either in direct current or in alternate current machines. Each of these four systems of exciting the field magnetism has its own merits for special cases, but none of them is perfect. Not one of these methods will insure that, with a uniform speed of driving, either the electromotive force or the current shall be constant, however the resistances of the circuit are altered.

But, though theory tells us that none of these systems is perfect, theory does not leave us without a guide. Thanks to the genius of M. Marcel Deprez, we have been taught how to combine these methods so as to secure in practice a machine which shall, when driven at a constant speed, give either a constant electromotive force or a constant resistance. A consideration of the various methods of combining the four systems of exciting the field-magnetism is reserved for the lecture on the dynamo in practice.

Meantime, it may safely be said that there is no such thing yet as a best dynamo. As with the different kinds of voltaic batteries, some of which are used for telegraph work, others for electric bells, and others for blasting, so is it also with dynamos. One form is best for one purpose and another for another. One gives steadier currents, another is less liable to heat, a third is more compact, a fourth is cheaper, a fifth is less likely to reverse its currents, a sixth gives a greater volume of current, while a seventh evokes a higher electromotive force. Indeed, in the present transitional state of our knowledge with respect to dynamo-electric machinery, it is safe to assert that, for a long time to come, there will be no finality attained to. As with the steam-engine, however, so with the dynamo-machine, there will probably be a constant and progressive evolution, finally settling down upon two or three typical forms, which will survive the innumerable comparatively crude machines which, as yet, have taken shape, and come into active service.

(TO BE CONTINUED.)

DETECTION OF METALLIC MASSES IN THE HUMAN BODY.*

BY ALEXANDER GRAHAM BELL.

(CONCLUDED FROM PAGE 192.)

Experiments Continued in Boston.

Mr. Tainter forwarded from Washington drawings of an improved apparatus he had designed to remedy the defects of the instrument shown in Fig. 18, in which the case, adjusting screws, &c., were all to be composed of ebonite.

Mr. Gleason constructed for me a number of such ebonite instruments differing slightly from one another in detail, and the apparatus shown in Fig. 20 combined the different points that had been approved.

The two coils A B were eccentrically arranged in two circular discs of ebonite, C D, and the adjustment was obtained by means of an ebonite key, O, like the key used for tuning pianos, which turned a cam, M, pivoted in the upper disc and working in a slot, N, in the lower disc.

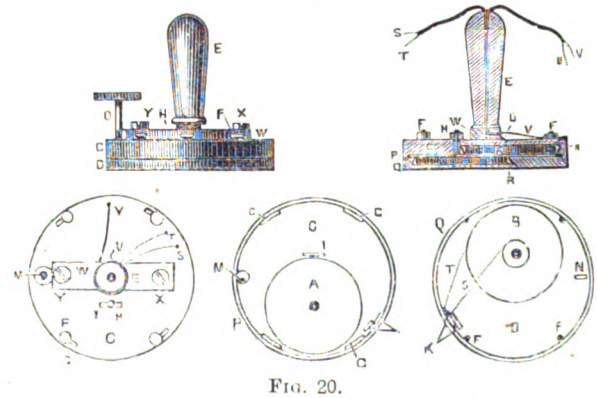

FIG. 20.

In order to prevent any movement of the coils, excepting that produced by the adjusting key O, each coil was placed in a recess turned out in its ebonite disc, the edges of which were bevelled as shown at R. Paraffin was then poured in so as to fill up each recess. But this alone did not prevent a slight pulsation of sound when the instrument was swayed from side to side, and a very slight pressure of the finger on the thin portion of the ebonite plate under the coil B was sufficient to destroy the balance.

This was remedied by strengthening this portion by means of a rod of ebonite, which passed up through the centre of the coil and through a slot, I, in the upper ebonite plate, and was clamped firmly after the adjustment of the instrument by an ebonite thumb screw, H. This, however, increased

* A Paper read before the American Association for the Advancement of Science at the Montreal Meeting, August, 1882.

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the difficulties of adjustment. When the coils were adjusted to silence, then the tightening of the thumb screw H, disturbed the balance; and if the thumb-screw H was tightened first, then the adjustment could only be made by a series of jerks, on account of friction. In practice we found it best to adjust the instrument *almost to silence*, and then the tightening of the thumb-screw H completed the balance.

This was the form of apparatus at which we had arrived at the time of the death of President Garfield.

The difficulty of adjusting the coils led me ultimately to the idea of the apparatus shown in Figs. 21, 22, 23, 24, which is the most practical form of the instrument yet devised.

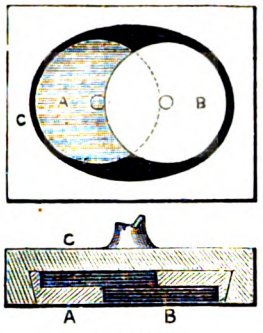

FIG. 21.

The two exploring coils A B (Fig. 21) are arranged as shown, in a recess turned out in a single block of wood C.

The coils are temporarily connected with a telephone, battery and rheotome in the manner shown in Fig. 1, so that they may be adjusted by hand to form a balance. When they have been arranged in their position of silence, the hollow in the block of wood C (Fig. 21) is filled with melted paraffin. Upon cooling, the two coils are found immovably fixed in one solid cake of paraffin.

As a matter of practice it is found impossible to fix the coils in this way exactly in their position of silence; but by means of two other very small coils, D E (Fig. 22) of insignificant resistance, forming a sort of fine adjustment external to the explorer, a perfect balance is easily obtained. In this instrument the swaying of the coils A B produces no effect upon the balance.

FIG. 22.

FIG. 23.

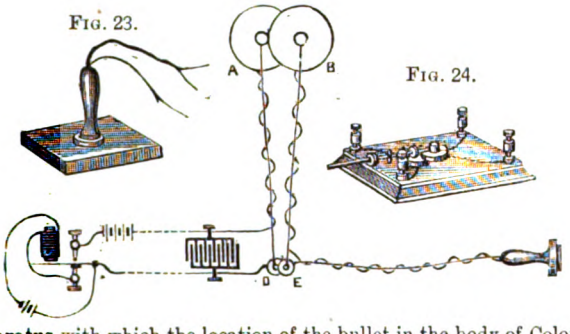

FIG. 24.

Apparatus with which the location of the bullet in the body of Colonel Clayton was discovered, October 7th, 1881.

The completed arrangement is shown in plan in Fig. 22, and the explorer and balancing coils are shown separately in perspective in Figs. 23 and 24.

On account of the small size and slight resistance of the balancing coils we were enabled to make the adjustable parts of the balancer of metal without practical interference with the sensitiveness of the exploring instrument, and this gave us the power of making very delicate adjustments of the balancing coils.

We found it advisable, however, to avoid placing metal over the sensitive area of the coils as had been done in the instrument shown in Fig. 24.

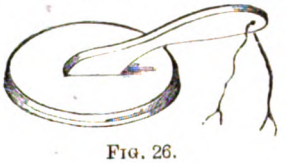

FIG. 26.

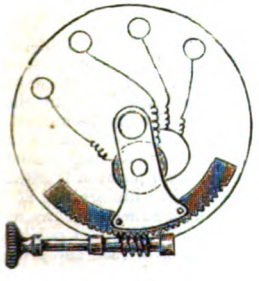

FIG. 25.

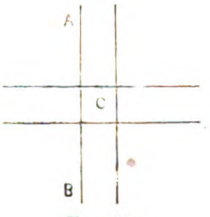

FIG. 27.

In the balancing apparatus shown in Fig. 25 (which is the most perfect one yet constructed), the lever to which the upper coil is attached is made of hard rubber.

In Fig. 26 is shown the most convenient form of case yet devised for holding the exploring coils.

By invitation of Dr. Frank Hamilton experiments were made with it at his office in New York, October 7, 1881, the instruments used being those shown in Figs. 22, 23, 24.

As this was the first successful application of the Induction Balance to the discovery of the situation of a ball in the body the position of which was previously unknown, I may be pardoned for entering somewhat into detail.

I shall quote from the *Medical Gazette*,* of New York, an account of the experiments written by one of the witnesses:—

The First Successful Application.

"On Friday, Oct. 7, by invitation, several medical gentlemen,† including the writer, met Professor Bell at the house of Dr. Frank H. Hamilton, in this city, for the purpose of witnessing the practical application of his improved instrument.

"The first person subjected to experiment was General Calvin E. Pratt, judge of the Supreme Court of the State of New York, and who is now a resident of Brooklyn. General Pratt, at the battle of Gaines' Mills, June, 1862, this being the second day of the famous seven days' retreat across the peninsula, received a ball in his left cheek, which penetrated through the nares and was lodged in the right antrum. Its presence at this time was recognised by his surgical attendant, Dr. Damainville, and its exact position has been known from that day until this, it having given rise at times to much pain and suffering.

"General Pratt has been seen by Dr. Hamilton and Dr. Damainville occasionally from that time forward, and they have from time to time urged upon him the necessity of its removal. General Pratt, however, was anxious to know whether Professor Bell's instrument would indicate its presence at the same point as declared by his surgeons.

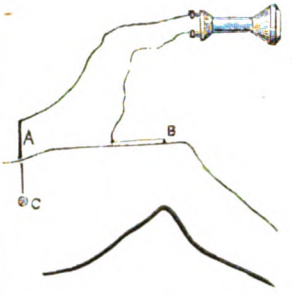

FIG. 28.

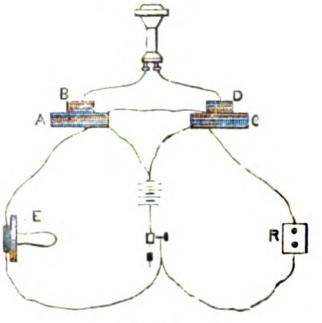

FIG. 29.

"The results of the experiment were conclusive and entirely satisfactory to General Pratt, the response being heard distinctly, but rather feebly, by every person present in the room. The feebleness of the response was supposed to be due to the fact that, owing to its situation and the peculiar form of the instrument containing the induction coils, it was impossible to bring the centre of its surface very near the site of the ball, the ball being situated very near the depression at the ala of the nose.

"The next patient was Colonel B. F. Clayton, who received a wound at the battle of Cedar Mountain, Virginia, Aug. 9, 1862.

"The missile was supposed to be an Enfield rifle ball, and the wound was supposed to be mortal by the medical director of General Banks's staff and his assistants. The ball passed through the sternal end of the left clavicle, and was supposed to have lodged in the muscles under the superior angle of the corresponding scapula. The injury was followed by complete paralysis of the left arm, continuing for a period of six months; and his arm has never yet been completely restored to its normal condition. He suffers a great portion of his time from pains in the arm, shoulder, and portions of the back.

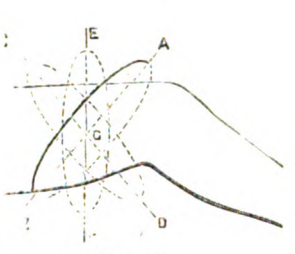

FIG. 30.

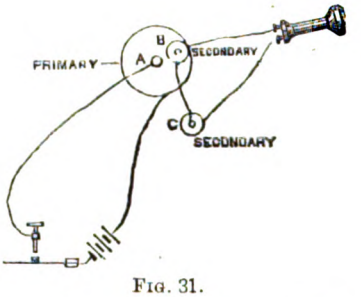

FIG. 31.

"Several small fragments of bone escaped through a fistulous orifice formed near the seat of the original wound.

"About eighteen months later an abscess opened on the front of the chest below the fifth rib and to the left of the sternum. Through this sinus his surgeon was able to carry a probe upwards and backwards towards the top of the shoulder several inches, and which sinus was supposed then to communicate with the seat of the ball on the back.

"Pleural adhesions were recognised by the medical attendant as having occurred in the upper part of the left thoracic cavity. He has been troubled occasionally ever since the injury with cough, expectoration, and

* See *Medical Gazette*, Oct. 15, 1881, pp. 347-349.

† "The following are the names of the medical gentlemen who were present, each one of whom verified personally the results and declared his entire satisfaction with every experiment that was made: J. C. Hutchinson, J. G. Johnson, and J. G. Allen, of Brooklyn; Elias Marsh, of Patterson, N.J.; Nathan Bozeman, J. H. Hunter, G. Durant, F. Delafield, L. Damainville, W. M. Chamberlain, J. H. Girdner, Frank H. Hamilton, and E. J. Birmingham, of New York."

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violent palpitations of the heart. A suspicion has even been entertained that the fistulous canal which remained open a period of eighteen months, and then became permanently closed, communicated with the bronchial tubes, but at no time was a suspicion entertained by him or his medical attendants that the ball was not lodged in the back and there closely encysted.

"We are disposed to mention as an evidence of Colonel Clayton's loyalty and faithfulness as a soldier that within six months of the receipt of the injury, and while the wound was still discharging pus and blood, he returned to active duty with his regiment and remained in the field until the close of the war.

"In the presence of the gentlemen assembled Colonel Clayton exposed his chest, and Professor Bell proceeded to move the coils across that portion of his back where the ball was supposed to be situated, the Colonel indicating the point underneath the superior angle of the scapula as that which had been fixed upon by himself and all the surgeons who had examined him as its exact seat. Although being buried underneath the scapula they had not been able to verify their diagnosis by the sense of touch. Repeated examinations were made over this region without any response both by Professor Bell and several of the gentlemen who were present.

"The instrument was then moved in every direction across the back and shoulders with the same result. There was an evident feeling of disappointment on the part of Professor Bell and all the gentlemen present, for no one entertained a doubt up to this moment that the situation of the ball was known and correctly stated by Colonel Clayton.

"It was not until the lapse of half an hour, and a thorough examination on the part of Professor Bell to determine if there was not some imperfection in the working of the apparatus, that it was suggested to move the instrument along the front of the chest.

"This was done by Professor Bell, and immediately he exclaimed, 'I have found it!' And such was evidently the fact, as was verified by the personal examination through the telephone by every gentleman present. The response when the instrument was moved over the seat of the ball was loud and distinct, and left no room for doubt."

After all the visitors present had had the opportunity of verifying my discovery of the sonorous spot on the chest of Colonel Clayton, experiments were made to determine as accurately as possible the exact position of the ball.

The exploring instrument (Fig. 23) was first held over that part of the chest where the maximum sound was obtained. The instrument was then moved slowly towards the left until the sound could no longer be perceived. The position of the centre of the instrument was noted, and a vertical line (A B, Fig. 27) was drawn with ink upon the skin through that point. This line indicated the boundary of the sonorous area towards the left. The experiment was then repeated by moving the instrument from the point of maximum sound towards the right, and also upwards and downwards, giving us the four boundary-lines shown in the diagram (Fig. 27). The bullet was thus located within a square, C, of about one inch.

"The exact situation of the ball," as described in the *Medical Gazette*, "was found to be within the thorax, probably in immediate contact with the inner surface of the ribs, the point being a little to the left of the sternum, between the third and fourth ribs, and two or three inches above the cicatrix on the front of the chest, where the sinus, long since closed, had evacuated itself, and in a direct line from this cicatrix towards the left shoulder, which indicated the line of the track of the original sinus."

Experiments with Needles.

During my absence from Washington and from all conveniences for experimenting personally with induction balance apparatus, I devised a method of verifying the indications of the induction balance and of ascertaining the exact depth at which a bullet lies beneath the surface. This method was communicated through Dr. Woodward to the surgeons in attendance on President Garfield, and it was made the subject of a special paper presented to the French Academy of Sciences, Nov. 7, 1881.

This method, although involving extremely slight pain, would ordinarily be used only as a preliminary to an operation for the extraction of a bullet. The arrangement is shown in Fig. 28. A fine needle, A, is connected to one terminal of a telephone, and the other terminal makes contact with a plate, B, preferably of the same material as that composing the needle. Place this metallic plate B against the surface of the patient's skin, and thrust the needle into that portion of the body where the bullet is believed to be lodged. When the point of the needle makes contact with the surface of the bullet C a galvanic battery will be formed naturally within the body, the two poles of which are respectively the leaden bullet C and the metallic plate B. Under these circumstances a click will be heard from the telephone each time the bullet is touched by the needle. This has been verified by experiments upon bullets buried in a joint of meat. The click, though feeble, is unmistakable.

I have no doubt that this method of exploration alone, without the induction balance, would prove of great service upon a field of battle, where the employment of complicated apparatus is impossible. Mr. Thomas Gleason has recently communicated to me the particulars of an experiment he witnessed, in the course of which this method was tried upon a living subject. The surgeon who conducted the experiment was unable to obtain any response from the induction balance employed, although from certain indications apparent to the sense of touch he believed that the bullet was located in the part of the body submitted to experiment.

To verify his supposition, a needle connected as above (Fig. 28) was thrust into contact with the hard substance perceived, but no response was made by the telephone. The surgeon, however, believing that the bullet had been found, etherised his patient, and proceeded with an operation, but discovered, when too late, that the bullet was not there.

Further Modifications of Induction Balance.

I sailed for Europe early in October, 1881, and have had no opportunity since of continuing my researches until quite recently. While I was in Europe, however, Mr. Sumner Tainter devised a new kind of induction balance which deserves mention here. The results obtained with this apparatus in its present form (Fig. 29) are not to be compared with those produced by the best instruments described above, but there are undoubtedly great possibilities of future development.

The important feature is that the exploring instrument E consists of *a single coil*, so that there is no possibility of any part of the explorer getting out of adjustment. All the adjustments are made upon the stationary part of the apparatus.

The current of the battery is divided between two equal circuits. One of the primary circuits contains the coil A and the exploring coil E, and the other circuit the coil C and a rheostat R. Coils A and C are exactly similar; and if the resistance introduced at R is equal to the resistance of the exploring coil E, an acoustic balance can be obtained by the adjustment of the secondary coils B D upon the primaries A C; but if the resistance introduced at R is different from that at E, Mr. Tainter states that no balance is possible.

When the apparatus is adjusted to silence the approach of a bullet to the coil E destroys the balance.

Although the great object of the researches that have been brought before you to-day has been to find that arrangement of balance which will detect a bullet at the greatest distance from the coils of the explorer, it must not be forgotten that in every case the instrument is more sensitive to the presence of a bullet placed *inside* the exploring coils than to one exterior to them. When, therefore, we seek the location of a bullet in one of the limbs, it may be advisable to use an annular coil large enough to slip easily over the leg or arm, as the case may be.

In Mr. Tainter's arrangement the exploring coil E (Fig. 29) might simply be a large ring consisting of a number of convolutions of thick wire which could be slipped over the limb, or the ring might consist of two coils, forming one side of a Hughes Induction Balance.

In either case the loudest sound will be produced when the bullet is in the plane of the ring, and its exact location should be deduced from three observations. Suppose, for instance, that with the ring inclined in a particular direction the maximum sound is obtained when the ring occupies the position A B. (Fig. 30). We know then that the bullet is in that plane. Now, incline the ring in some other direction and explore again. Let the position of maximum sound be now C D. We know then that the bullet is somewhere on the straight line formed by the intersection of the planes A B and C D. It is only necessary then to make a third observation with the apparatus so inclined that the plane of the ring cuts this straight line, for instance, the position E F. The point of intersection of the three planes G is then the exact point occupied by the bullet.

I shall conclude this paper by the description of an experiment made in Newport, R. I., a few days ago. The results are so unprecedented in my experience that I feel they cannot be received as implicitly reliable until the experiments have been repeated and verified.

I had arranged upon a table three coils (as shown in Fig. 31). The large flat primary coil A was connected with a battery of four Bunsen elements and an interrupter, as shown, and the two small secondaries of fine wire B C were connected with a telephone.

The secondary B was moved about on the primary A until a position of silence was obtained. Upon bringing a leaden bullet near C the balance was disturbed and a distinct sound produced from the telephone. There is nothing very strange about this when we know that the distance between A and C was only 15 centimetres, so that C was well within the field of induction of A; but what did seem extraordinary was that the approach of the large steel blade of a penknife to the coil C produced no effect! The iron diaphragm of a hand telephone brought close up to the coil C produced no sensible disturbance of the balance, whereas a small disc of lead produced quite a marked effect. A disc of copper the size of a telephone diaphragm also produced a good effect, but the sound was not sensibly louder than that due to the small leaden disc. A diaphragm of zinc occasioned a feeble, but distinct, disturbance of the balance. It is, unfortunately, the case that in all the forms of induction balance described above lead gives the poorest effect of all metals. If people would only make their bullets of silver or iron there would be no difficulty in finding them in any part of the body! In the apparatus shown in Fig. 31, however, it seems (unless subsequent experiments should reveal some fallacy) that we have an arrangement which is sensitive to lead and not to iron, or, at at all events, which is more markedly influenced by lead than iron.

It is hardly necessary to state that, when the coil C was removed to a considerable distance from the primary A, no effect was produced by the approach of metal to the coil C.

I have in this paper brought before you an outline of a labour of love pursued through many anxious days and sleepless nights. However imperfect or disappointing may be the results so far achieved, they are sufficiently encouraging to enable us to look forward with confidence to the attainment of still greater perfection.

I hope to continue these researches in the future; and certainly no man can have a higher incentive to renewed exertion than the hope of relieving suffering and saving life.

THE DEVON AND CORNWALL ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

An extraordinary general meeting of the members of this Company was held at the Cannon-street Hotel on the 10th inst., "for the purpose of considering the present position of the Company, and (if it should be deemed expedient) to pass the following resolution:—That in the interests of the large majority of the shareholders of the above-named Company, the said Company do, on the hearing of the petition of Henry Whorlow for the winding up of the above-named Company, consent to an order being made by the judge to whose court such petition is attached."

Mr. W. H. Owen presided, and alluded to the decision arrived at by the previous meeting to oppose any legal proceedings as well as any attempt that might be made to wind up the Company. Mr. Whorlow's petition contained several allegations, and many of them stated that the prospectus was incorrect as to the Lane-Fox lamp. He then stated that the Company was now sued by thirty-seven shareholders, who were endeavouring to obtain the return of the money which had been paid by them on their shares. The directors had, in these circumstances, considered it right to call the shareholders together, for it would be most unfair that a portion of the shareholders should get back 20s. in the pound at the expense of the other shareholders, who, to meet such claims, would have to pay another call. The directors believed that it would be to the advantage of th majority of the shareholders that they consent to an order being made on

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Mr. Whorlow's petition, inasmuch as they were advised that an order would take effect from the date of the presentation of the petition, namely, November 1st last, and such proceedings of hostile shareholders had been commenced subsequent to that date. Those shareholders would only rank equal with all the other shareholders in the distribution of the assets. If, however, Mr. Whorlow's petition were dismissed by the Court the hostile shareholders might obtain priority over the other shareholders. He concluded by proposing the resolution.

Mr. G. BRAGGINTON seconded the motion, and suggested the advisability of appointing a small committee in connection with any claim this Company might have against the Great Western Electric Light Company for misrepresentation as to the sale of their concessions to this Company.

At the request of Mr. Fewings, the voting power of the meeting was counted, and the chairman said that the proxies forwarded in favour of the resolution represented 603 votes and the shareholders present had 418 votes.

Mr. FEWINGS stated that he was in entire accord with the resolution which had been so ably proposed by the chairman. From the contents of the circular accompanying the notice convening the meeting it must strike everyone who had carefully considered it that the only course open to the shareholders was to prevent the hostile shareholders from being transformed, as they would be if the petition were not assented to, into creditors of the Company, who would be entitled in that case to receive full payment of their money. He wished to know if a legal opinion had been taken on a matter of very grave and serious importance. A mistake, to say the least of it, had unfortunately crept into the prospectus, a mistake which had left Mr. Justice Chitty to make an order on the application of the Hon. W. F. Cadogan on the ground of misrepresentation. That misrepresentation was due to somebody, and he wished to know if counsel's opinion had been taken as to the origin of the error, and who was responsible for it.

The CHAIRMAN stated that counsel's opinion had been taken, but the present was not an opportune moment to go into the question as to who was liable for the mistake. In case of the Company going into liquidation it would be the duty of the liquidator to go fully into this matter and to press their claims if necessary. He was strongly of opinion that some one was liable. The opinion given to the directors was a very unsatisfactory one, because it was to the effect that a general mistake had occurred all round and under a state of things in which it would be very difficult to make any individual liable. That was the whole purport of the opinion which had been given by Mr. Romer, Q.C. He did not agree with the opinion, and it would become the duty of the liquidator to press the matter and obtain a judicial opinion on it.

Mr. HENRY MAUDSLAY stated that about a third of the shareholders of the Company was not represented at the meeting either by person or proxy. There were thirty-seven shareholders who had brought actions, but there were only thirty-six on his paper who represented 3,267 shares of an amount of £8,617. If each of those shareholders had his money returned in full the Company would be in a very serious and anomalous position, and they would have to make another call on the shareholders to obtain a sufficient amount of money to be divided among those shareholders who had been litigious. He then referred to the anxious time which the directors had had, and to the onerous duties which had been discharged by Mr. Owen, the chairman, who had endeavoured to look after the interests of the shareholders in every possible way, while the expenses had been cut down to the greatest extent. Three of the members of the Board were original directors. He himself became a director from the force of circumstances, having been connected with the Great Western Company, and having taken 1,000 shares in this Company, every one of which he still held. He did have an opportunity of making a considerable profit out of those shares, but he had not trafficked in them. He still remained a director of this Company in the hope of being able to represent the interests of the shareholders. There were other similar companies who had fallen into the same error as this Company had, and there had been considerable difficulty from this circumstance throughout the country. Owing to this unfortunate mistake, whoever was responsible for it, they were now suffering for it as shareholders, but the best possible way was to endeavour to get out of it with the least possible cost. The directors were obliged to confess that an error had been made, but not by them. The Devon and Cornwall Company was a sub-company of the Great Western Company, and they purchased from that company something which it appeared the Great Western Company did not possess to sell. It was possible that they might be able to put things in such a way as to induce the Great Western Company to return the money, this Company giving back the concessions. He had asked the Board of the Great Western Company to consider whether, under the circumstance of their having sold what they did not possess, they would not give this Company back what had been paid to them. That was the principal reason why he left the Board of the Great Western Company. With regard to the claims on the Company, they amounted, as he had said, to £8,617, and they had now owing £4,200, and unpaid calls amounting to about £3,000. On the 16th November they had £5,153 in hand.

A SHAREHOLDER: The uncalled capital and the money in hand will about meet these claims?

Mr. MAUDSLAY replied in the affirmative.

Mr. BRAGGINTON considered the explanations they had received very satisfactory, and thought it would be most wise, under the circumstances, to agree to the course which had been adopted.

Mr. PARSONS, on behalf of the Great Western Company, whose proxy he held, said he should not vote for or against the liquidation, but he should leave the question entirely in the hands of the shareholders.

Mr. FEWINGS said a most material point occurred to him in connection with the resolution which had been made by Mr. Parsons. At the last meeting the chairman stated that there was a clause in the contract whereby this Company bought the electric light of Devon and Cornwall from the Great Western Company to the effect that if they resolved on liquidation, or the Company get into any shape of winding up, they would actually forfeit by that step all rights against the Great Western Company or any claim for the return of the money they had paid, and that the licenses acquired from the Great Western Company would revert to the Great Western Company, and that the Devon and Cornwall Company would get no compensation whatever. He (Mr. Fewings) thought that a very unbusinesslike clause, and he desired to know if they had been advised since that they would not forfeit the license by winding up.

The CHAIRMAN, in reply, stated that when the agreement was made with the Great Western Company, whereby it was provided in case of coming to a winding up of this Company the concession should revert to the Great Western Cpmpany, it was never supposed for a moment that there was going to be such a state of things as now existed, namely, an error in the very thing which the Great Western Company was selling to this Company. They had only, however, to do one of two things—to wind up, or to go on. If they went on, a further call would be made probably to the extent of all the unpaid capital to meet the claims upon them, so that on the one hand they would have an empty concession, and on the other all these hostile proceedings. A communication had been made to the directors of the Great Western Company with regard to the return of the money paid them by the Company, but it came to nothing, because the Great Western Company repudiated all liability whatever.

After a slight further discussion, the CHAIRMAN put the resolution as above, and declared it carried unanimously.

Some further discussion took place with regard to the suggestion made by Mr. Bragginton as to whether a committee should be appointed to advise and to watch over the liquidator.

Mr. RYLANDS (the solicitor of the Company), however, alluded to certain objections against the appointment of the committee, stating that a Court always looked rather jealously on any interference, and further stated that the committee would cause additional expense.

The CHAIRMAN said that the directors would give every assistance they could on behalf of the shareholders, and that they would do their utmost throughout to protect the interests of the Company. He expressed his unabated confidence in electricity, and the thanks of the directors to the shareholders for their kindness and forbearance.

On the motion of Mr. MORTIMER, seconded by Mr. MAUDSLAY a vote of thanks to the chairman brought the proceedings to a close.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

The tenth ordinary general meeting of this Company was held at the City Terminus Hotel on the 10th inst., under the presidency of Sir H. D. Wolff, M.P.

The SECRETARY (Mr. R. M. Cunningham) read the notice convening the meeting, and the report of the directors, which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN, in moving the adoption of the report, referred to the negotiations with the Brazilian Government, to which he alluded last year, which were being carried on at that time by Mr. Cunningham on behalf of the Company. These negotiations could not be considered as concluded. As he said last year, the question was one of great delicacy, affecting not only the Company's relations with the Brazilian Government, but also their relations with other telegraph companies; and thinking that it would take some time to carry them out they thought it better to place their house in order in this country—to place themselves in as good a position as possible, as they thought it was due to them to strengthen their position in connection with these negotiations. Last year a commission was appointed by the Brazilian Government to look into the negotiations and proposals which Mr. Cunningham was instructed to carry through, and the Government generally, and he believed the Brazilian public, looked with considerable favour on the Company's proposals. In a country, however, which was subject to constant changes of government, and where questions of this nature were submitted to the decision of the popular assembly, it appeared to the directors, as he had said, that the negotiations would take a considerable time before they could be carried through, and Mr. Cunninghamwas consequently instructed to return to England. They still believed that the Brazilian Government looked favourably at their proposals, and that at some time or other not specified, but he hoped not very remote, they might be able to recommence negotiations with the Government. Turning to the report, he stated that they had opened communications with Maldonado and Ceara. As regarded Maldonado they had not to lay any new cable, as it already existed, but there was no station, and the Uruguayan Government requested the Company to open a station there, and had given the Company a subsidy sufficient to pay the working expenses, and therefore there could be no loss there, and he hoped there would be a profit. As to Ceara they had opened a new station in that very important and rising place, and had done so by laying an entirely new line between Maranham and Ceara, thus dividing the section which originally went from Maranham to Pernambuco. They had also entered into a contract for the purchase of a new repairing ship, and their reason for doing that was on account of the great length of the Company's system, which altogether, with the lines they worked for others, was 3,700 miles. By having two steamers, one at either end of the line, they would not only improve their communications altogether, but save a very large sum of money which they were annually exposed to lose by the length of time which it took to make repairs. They thought that the price of the steamer would be fully recouped by the lesser time occupied in repairs. With regard to the earnings, they had to a certain extent decreased since last year, but still the total receipts were comparatively satisfactory. The working expenses had been reduced by £8,500, and the maintenance for the year decreased by £10,000. One of the great causes of the bad returns of the Company had been owing to a cable having been originally laid which was not suited for the purposes required. A deep sea cable was laid in shallow water, and was exposed to risks to which a sheathed cable was not exposed. They had found that wherever there had been a sheathed cable the repairs had been very insignificant and very rare, whereas where the old type of cable had been laid the interruptions were very frequent. Therefore, a very large sum had at different times been spent, not merely on ordinary cursory repairs, but on renewal of the lines, and the result was to a large extent satisfactory to the Company; for though they had spent £41,000 a year on repairs, together with certain sums charged to capital, they had out of a total line of 2,500 miles, new cable for a length of 1,500 miles, and therefore three-fifths of the cable had been entirely relaid, and might be considered to have given a new lease to that portion of their system. They also at the present moment possessed money by which they could, if they thought it right, relay the whole of the rest of the line. They trusted, however, that that would not be necessary, because the deep sea cable lying n

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deep water, the interruptions and accidents were not frequent, and they considered at the present moment that their cable was in a very fair state of repair, and would only require comparatively small renewals and alterations and repairs for the next few years. Although the earnings during the past year had shown a small reduction to those of the preceding year they were now to a certain extent recovering, and for the first quarter of the current year, namely, from the 1st of October to the 31st December, the traffic had shown an increase of something over £3,000. They had now finally closed the litigation which had been going on, and had received an additional sum of money, and the question now before them was the reduction of the capital with the view of paying a dividend. They had applied to some distinguished counsel—the Attorney-General and Mr. Horace Davey, Q.C.—with the view of inquiring how they might proceed under the new prospects of the Company, and not only had they submitted cases to counsel, but the directors had on more than one occasion had interviews with them, and the course they were now adopting was one recommended by those two eminent gentlemen. The project was to reduce the share capital of the Company by a sum of money representing £5 a share, which would include the whole loss on the central American cable and also certain depreciation of instruments and renewal of cable and repairs of the ship which heretofore had not been dealt with. It would be the duty of the directors to ask the shareholders their consent to this reduction of capital, by which means they would have a sum of money which, as soon as the Court had ratified the proposal—which he hoped would not take very long—which would enable them to declare a dividend equal to 3 per cent. on the whole of the reduced capital and to place £12,000 to reserve and carry forward a balance. He could not help thinking that this course would recommend itself to the approval of the shareholders, because it was perfectly plain that there was no good counting as capital what was not capital, and the shares were really not reduced in value by the frank admission that a loss had been made and they had written it off. For a long time £15 per share had been the real capital of the Company, and on that £15 a share he trusted that they might be able to keep up a dividend. In fact, by the recovery of so large a sum as that now standing to the Company's credit, they would be able fairly to expend sums on renewal out of the amount recovered which had hitherto been very unfairly placed upon revenue owing to the exigencies of the Company. As to the question of dividing the shares into preferred ordinary shares, bearing 5 per cent. cumulative dividends, and into deferred ordinary shares, the division had been forced on the directors in a manner so influential that they had no alternative but to put it before the meeting. But he might say that it would be quite optional on the part of the shareholders to avail themselves of the division. Those who preferred keeping their shares as they were at present, and not dividing them, would have their dividends paid on their shares as they stood—£15 each. The proposal would simply enable those who chose to divide to do so. He did not care to hold out hopes which might not be realised, and they all knew the great vicissitudes which the Company had gone through. But at the same time it was his hope that they would be able to keep up a dividend, and meanwhile they proposed, as soon as they found themselves released from the labours which the consideration of this reconstruction had given them, to turn their attention once more to the question of the negotiations with the Brazilian Government. Notwithstanding the competition of the Brazilian land lines, which was really very unfair competition, the Company did not do so badly as might be anticipated, because their service was superior to the Brazilian service in speed, accuracy, and, he thought, secrecy, and those qualities were appreciated by the Brazilian Government, as was shown by the fact that, notwithstanding the competition of the Brazilian Government lines, the Company still kept up their traffic pretty much to the old figures. He concluded by moving the adoption of the report and accounts.

Mr. W. S. ANDREWS seconded the motion.

The CHAIRMAN, after having replied to a few questions, intimated that the directors had considered it their duty, having regard to the enormous labours and the success attending them which had been undertaken by the managing-director (Major Wood) and by Mr. Cunningham, to give those gentlemen a substantial recognition of their services out of the funds of the Company. They had allotted to Major Wood £1,500, and to Mr. Cunningham £750.

The motion was then unanimously adopted, and the retiring directors and auditor were afterwards reappointed.

Mr. PIKE then alluded to the value of the services which the directors had rendered in getting back for the Company no less than £140,000 from persons formerly connected with the Company. It would not be considered wrong by commercial men to give them 5 per cent. on the amount recovered; but he was not going to make such a proposition. But it was his intention to move a resolution (which he afterwards formally submitted), requesting the directors to give notice for the next meeting that a proposal would be brought forward to transfer to the directors, in recognition of the services to which he had alluded, 700 of the shares which had been given back as part of the arrangement made in connection with the late litigation.

Mr. SUTTON seconded the motion, which was supported by Sir W. P. Andrew.

Some further discussion took place respecting the matter, in the course of which

Captain COTTON did not agree with burdening the Company as was proposed, and thought that each shareholder who appreciated the action of the directors should himself out of his own pocket show his appreciation of that action. For his own part he held 100 shares, and was prepared to give 10 per cent. out of his dividend. He afterwards moved an amendment to the effect that the matter should be postponed till they paid a dividend.

Mr. PIKE put the amendment and the resolution, and declared the latter carried.

An extraordinary general meeting was then held, and the chairman moved the first of the special resolutions of which notice had been given, reducing the capital from £1,398,200, divided into 69,910 shares of £20 each, to £1,048,650, divided into an equal number of shares of £15 each.

Mr. C. W. EARLE seconded the motion, and it was carried unanimously.

The CHAIRMAN, in reply to a question, stated that they would have to apply for a new quotation to the Stock Exchange for the preferred and deferred shares, the ordinary shares remaining as they were. He then moved the second resolution, dividing the shares as proposed. The motion having been seconded,

Mr. ROKEBY PRICE did not think the Committee of the Stock Exchange, of which he was a member, would have any difficulty in giving a quotation to the shares. But he objected to the proposal as a principle. He contended that it would be no advantage whatever to the shareholders to split the shares into two classes. There would be no more capital and no more earnings, but the only thing that it would do would be to produce enormous fluctuations in the value of the preferred and ordinary shares; and as regarded those who retained their shares as at present and did not divide them, they would find, as in other cases, that there was no market for them. They would, in short, have a useless division, and the only effect would be that there would be a great increase in speculative transactions. He believed he was expressing the best opinions on the Stock Exchange in making these remarks against the proposed division of the shares.

Mr. COTTON acquiesced in the remarks of Mr. Price.

The CHAIRMAN stated that they had two sets of proxies, one relating to the business of the ordinary meeting and the other for the extraordinary meeting, and, therefore, those who had sent their proxies for the extraordinary meeting were clearly in favour of this resolution, and he must put the motion, which he proceeded to do. He announced that the resolution was lost on a show of hands, and the directors did not consider it wise to have a poll on the subject, and, therefore, he considered that that proposition was negatived. He then moved the third resolution, substituting for Article 40 another article similarly numbered, authorising the Board to appoint a managing director who might be a member of the Board, but who should not be subject to retirement by rotation.

The motion was seconded and carried unanimously.

On the motion of Mr. PRICE, seconded by Mr. ROBINSON KENDAL, a vote of thanks to the chairman and directors terminated the proceedings.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JAN. 10.		BUSINESS DONE WEEK ENDING JAN. 10. Highest.		Lowest.
Anglo-American	49½,	50½	50½	.....	50
Do. Preferred	81¼,	82½	82½	.....	80½
Do. Deferred	18¼,	19¼	19¼	.....	18½
Brazil Submarine	11¼,	12¼	12¼	.....	11 15-16
Cuba	9½,	10½	—	.....	—
Do. Preference	17,	18	17	.....	17
Direct Spanish	6½,	7	6¾	.....	6¼
Do. Preference	16,	17	16¼	.....	16½
Direct United States Cable	12,	12½	12¾	.....	12
Eastern Telegraph	11,	11½	11 5-16	.....	11 1-16
Do. 6 per Cent. Preference	13½,	13¾	13¾	.....	13 7-16
Do. 5 per Cent. Debentures, 1899	105,	108	.....	—	..... —
Eastern Extension	12,	12½	12¼	.....	12 1-16
German Union	10½,	10¾	11¼	.....	11¼
Globe Telegraph and Trust Company	6½,	6¾	6 11-16	.....	6¼
Do. Preference	12,	13	12 15-16	.....	12¾
Great Northern	12,	12¼	12¼	.....	12 1-16
Indo-European	32,	33	.....	—	..... —
Mediterranean Extension	1¹,	2	.....	—	..... —
Do. Preference	6,	8	.....	—	..... —
Reuter's	12,	12½	.....	—	..... —
Submarine	250,	255	.....	—	..... —
West India and Panama	1¼,	1½	.....	—	..... —
Do. 1st Preference	7,	7½	.....	—	..... —
Western Brazilian	7¾,	8	.....	8¼	..... 7¾
West. Union 7 per Cent. 1st Mortgage	122,	126	.....	125½	..... 125½
Do. 6 per Cent. Sterling Bonds	102,	105	.....	—	..... —

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¾	.....	13-16	 11-16
Oriental	⅛,	¾	.....	¾	..... ⅝
United Telephone	10¾,	11¼	.....	11¼	 11

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	7¾,	8¼	.....	8 11-16	..... 7½
Do. (fully paid)	12,	15	.....	16	..... 13½
Gulcher (£1 10s. paid)	—,	—	.....	—	..... —
Hammond Light	3,	3½	.....	3 11-16	..... 3½
Eastern Electric (£4 paid)	1¼,	1¾	.....	1¾	..... 1¾
Pilsen, Joel, and General Electric	1,	1½	.....	1½	 1
Swan	1½,	2	.....	1 15-16	..... 1¾
Maxim-Weston	⅜,	½	.....	½	..... ⅜

TRAFFIC RECEIPTS FOR DECEMBER, 1882.

COMPANIES.	Dec., 1882.	Dec., 1881.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,741	59	—
Direct Spanish Telegraph Company	1,346	1,458	—	112
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	49,610	49,844	—	234
Great Northern Telegraph Company	17,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SLIP

SPAIN.—The cable between Falmouth and Bilboa is interrupted.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 12 were £3,540.

BRIGHTON.—The Town Council have resolved to oppose the application of the Union Electric Light Company for a provisional order.

BIRMINGHAM AND MIDLAND INSTITUTE.—The presidency of the institute for the ensuing year has been accepted by Sir William Thomson, F.R.S., &c.

ELECTRICAL EXHIBITION AT VIENNA.—The regulations and conditions as to exhibits at this exhibition will be found in another page of this week's issue.

MR. FAWCETT.—The medical advisers of Mr. Fawcett are most urgent in insisting that he should have complete rest, bodily and mental, for at least two months.

STOCKPORT.—The Town Council of Stockport have abandoned their intention of applying for a provisional order to enable them to supply electricity for lighting and other purposes in this town.

UNIVERSITY COLLEGE.—Professor G. Carey Foster, F.R.S., was to have delivered a public lecture on "The Sources and Applications of Electricity" at University College, Gower-street, on Thursday evening.

THE ROYAL SOCIETY.—On Thursday, Mr. R. H. M. Bosanquet was to have read a preliminary paper before this society "On a Uniform Rotation Machine, and on the Theory of Electro-Magnetic Tuning Forks."

ELECTRIC WORKS COMPANY.—A meeting of this company is to be held at 3, Bucklersbury, E.C., on the 17th February, at 11 a.m., to receive an account of the manner in which the winding up of the company has been conducted.

AURORA BOREALIS.—A magnificent display of the aurora was witnessed at Lerwick, in the Shetland Islands, on Sunday night (the 7th inst). Local accounts describe it as even more brilliant than the display of December last.

DIRECT UNITED STATES CABLE COMPANY.—The board of this company have resolved upon the payment of an interim dividend of 5s. per share, being at the rate of 5 per cent. per annum, for the quarter ended Dec. 31, 1882.

STUDENTS' COLUMNS.—We regret to have again to postpone our Students' Column to a future issue; the continuation of our Review of the Year, and an unlooked-for length of Correspondence, have combined against us in this matter.

APPOINTMENT.—The directors of the Metropolitan Brush Electric Light and Power Company have appointed Mr. Radcliffe Ward, formerly chief electrical engineer to the British Electric Light Company, to be chief electrical engineer to their company.

ELECTRIC LIGHT AT LONG EATON (NOTTS.).—Some of the leading lace makers in this district have determined to adopt the electric light, and have placed the work in the hands of the Hammond Electric Light and Power Supply Company.

RESIGNATIONS.—Mr. J. Kenneth D. Mackenzie, A.S.T.E., has resigned the appointment of electrical engineer to the Metropolitan Brush Electric Light and Power Company.—Mr. D. P. Wingrave has resigned the managership of the London and Provincial Electric Lighting and Power Generating Company.

CUBA SUBMARINE TELEGRAPH COMPANY.—The directors of this company have resolved, after providing for the dividend on the preference shares, and placing £1,325 to the reserve fund, to recommend the payment of a dividend on the ordinary shares at the rate of 7 per cent. per annum, free of income-tax, leaving £1,074 to be carried forward to the current half year's accounts.

ORIENTAL TELEPHONE COMPANY.—An extraordinary general meeting of this company is called for the 24th instant, to be held at the Cannon-street Hotel, at 12 noon. The meeting will be asked to consider and pass certain resolutions rescinding and altering some of the Articles of Association, in order to confer upon the directors the power of declaring an interim dividend.

CONVERSAZIONE.—Last week the Birmingham and Midlands Institute gave their annual *conversazione*, in which electricity played an important part. Amongst other things, the operations of boiling and roasting by means of the current were shown to those present. A number of other familiar lecture experiments were also carried out. The current was supplied by Messrs. Winfield and Co.

NATIONAL TELEPHONE COMPANY, NOTTINGHAM.—The superintendent of the Nottingham fire station mentions that during the last year eight fires were reported by telephone through the Central Exchange and various police stations connected by the above company's system, and many thousands of pounds worth of property was saved owing to the rapid means of communication afforded.

ATLANTIC CABLE TRAFFIC.—It is stated that arrangements have been completed for the establishment of an independent submarine telegraph office in New York. The Direct United States and the Compagnie Française cables will be worked from this office, and will be entirely independent of the existing land wires in America, while they will at the same time be open to receive messages from any of the land wire systems of the United States.

ASSOCIATION OF CHAMBERS OF COMMERCE.—The twenty-third annual meeting of this association will take place on the 20th, 21st, and 22nd of February at the Westminster Palace Hotel. Amongst the subjects for discussion is a recommendation from the London Chamber to the effect that the Executive Council should prepare a report on the whole subject of inland postal and telegraphic reform. Proposals from other chambers regarding telephone communication, cheaper short telegrams, &c., will also be considered.

ELECTRIC LIGHTING CONTRACTS.—The Electric Carbon Storage and Apparatus Manufacturing Company of Leith have secured contracts for lighting the whole of F. Fowler and Co.'s Steam Plough Works, requiring 80 arc lamps and 900 incandescent lamps.—Messrs. Key and Son three steamers, with arc lamps for loading, &c., and incandescent for state cabins, saloons, &c.—Messrs. Kelly and Co., Kingston Works, by means of storage batteries and dynamo.—Messrs. Hyams' establishments in Edinburgh and Glasgow, and one of the Edinburgh theatres.

THERMO-ELECTRIC BATTERIES.—We have often pointed to this branch of electricity as offering a fine field for investigation, and no doubt shall soon find that many minds have been attracted in this direction. Dr. Paget Higgs tells us that he has long been making experiments with a view to practical work in domestic lighting, and that he has at length devised a system which answers well. The thermo-battery he has invented is unique and of a single metal, actuated by the ordinary fire and connected with a storage battery. We

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have before us a pretty full description of the system, but at present it would be impolitic to say more on the subject.

THE "SUN" LAMP.—This lamp, as supplied by the Electric Sun Lamp and Power Company, of St. Margaret's Offices, Victoria-street, Westminster, has just been installed at Messrs. Singleton and Cole's premises, Wolverhampton, with success. It is also being erected at Messrs. Finlay and Co.'s Lace Curtain Works, Doune, Scotland, the Bowling Iron Works, Bradford, and establishments at Glasgow, Salford, and elsewhere. The central station of the company, 6, Riding House-street, Portland-place, W., is now complete, and application has been made to the local vestry to light a part of London from that centre. An exhibition of the light will shortly be made at the station.

THE FERRANTI-DYNAMO MACHINE.—We are informed that at Messrs. Copestakes, Hughes, and Crampton's works at Nottingham, where the first Ferranti installation has been made, it is found possible to turn out any number of lights without altering the speed of the dynamo machine. At the present time there are 100 C Swan lamps in use there, and recently, on the occasion of an inspection of the lights, one block after the other was turned out, until only one was left burning in the engine house. This installation has given so much satisfaction that it is, we understand, about to be increased to 500 lights. The work has been executed by the Hammond Electric Light and Power Supply Company.

ELECTRIC LIGHTING OF SHIPS.—The "Hawarden Castle," a new steamer recently built for Messrs. Donald Currie and Co.'s South African Mail Service by Messrs. John Elder and Co., of Fairfield, Govan, on the Clyde, is to be lighted by means of incandescent lamps. She was only launched last week, and was christened by Mrs. Gladstone, wife of the Premier. The "Hawarden Castle" is 393ft. 6in. long over all, 48ft. broad, 33ft. deep, and has a gross tonnage of about 4,300 tons. The "Ionic," another new steamer, recently built for the White Star line of American steamers by Messrs. Harland and Wolff, of Belfast, is to be lighted by the same system. She is 440ft. long, 44ft. broad, 32ft. deep, and has a gross tonnage of 5,000 tons.

AN ARMY TELEGRAPH CORPS.—At the recent distribution of medals to those members of the Post Office Volunteer Corps (24th Middlesex) who took part in the Egyptian campaign, Colonel Du Plat Taylor announced that he had received through Colonel Clive a despatch from the Secretary for War, granting him permission to raise two companies of Volunteer Telegraphists to form part of the Post Office Volunteers. These companies will have a purely Volunteer organisation, but will be instructed in the duties of Army Field Telegraphists. The medals were presented by the Duke of Teck, the recipients being Captain Viall, three sergeants, two corporals, and 28 men. Major G. C. Sturgeon, who commanded the detachment in Egypt, received his medal from Her Majesty the Queen some weeks since.

TELEGRAPHISTS AND HOTEL KEEPERS.—At the Berkshire Assizes, held at Reading last week, Thomas Pocock, proprietor of the Bacon Arms Hotel, Newbury, was charged with refusing to accommodate four telegraph clerks. In September last Lord Carnarvon delivered a speech at Newbury, and four telegraph clerks were sent from London to transmit it to the morning papers. The clerks engaged beds at the Bacon Arms Hotel, but as they did not return until nearly three in the morning the landlord refused to admit them. It was raining heavily at the time, and three of the clerks became ill in consequence of exposure, having had to remain out all night. For the defence it was alleged that the clerks were abusive and could have come to the hotel earlier. This was denied. Mr. Baron Huddleston said that all keepers of hotels were bound to accommodate travellers. He ordered the defendant to be bound over in his recognisances of £100 to come up for judgment if called upon.

TATE'S ENGINE STOPPER.—Some weeks since (see *The Electrician*, October 21) we illustrated and described Tate's electric apparatus for closing the valve of an engine and thereby stopping it. This apparatus is now at work in some of the large mills at Dundee, in Scotland. In describing the apparatus at work, the *Dundee Advertiser* of Tuesday last says:—"The huge engine in Manhattan Works (Colonel Sandeman's), working at from 600 to 700 horse-power, and driving a fly-wheel of about 35 tons weight, formerly took two minutes to come to rest after the steam had been taken off. This apparatus has been fitted to it, and the ponderous engine is now brought up in thirty seconds. To see this powerful, majestic piece of machinery, the developer of power for a large range of works, almost immediately brought to a standstill by the mere touching of a button at the far end of the building is an impressive illustration of the easy control of enormous force by wisely ordered arrangements. To mill-owners the utility of the apparatus will be evident."

EDISON'S SYSTEM IN MELBOURNE.—The *Melbourne Age* for November 29, a copy of which we have just received, says:—"The chamber of the Legislative Council was lighted by Edison's electric light last evening. When the members met the room was lighted as usual by gas, the large glass chandelier only being used. About six o'clock the standard gas lights were lighted, shortly after which the electric lamps began to glow, and in about one minute the entire chamber was most brilliantly illumined, many members being able to read their papers and notes with a distinctness and clearness never before experienced. There was but one opinion expressed, and that was to the effect that Edison's light was a complete success, the only unsettled point being that of cost. The chamber was prepared for this lighting in a very few days with fittings Major Flood Page brought with him from England." The *Argus* of the same date gives a few more details, from which it appears that altogether 46 lamps were used. This paper describes the temperature of the house as having been "very much pleasanter than it has ever been in the memory of the oldest frequenter of the House."

ELECTRIC LIGHTING IN STOCKPORT.—Messrs. Faulder, of Stockport, have lighted part of their premises by means of five Pilsen arc lamps, the current being supplied by an A Gramme dynamo machine, driven by a three horse-power engine. A member of the firm has given an estimate of what it costs him to light his shop by this means, and calculates it at 1d. per hour per lamp. This he states to be about the same price that he originally gave for gas. With the electric lights, however, he gets more light for his money. We leave all the responsibility of these figures with Messrs. Faulder. The lamps were erected by Messrs. Emerson and Murgatroyd, of Stockport, whose electrician has kindly sent us some tests he made after starting the machine and lamps, which he thinks may be of interest, seeing that it is unusual to work Pilsen lamps from Gramme machines. The data he sends us are as follow:—A^2 Gramme machine; resistance of field magnets, 4·3 ohms; resistance of bobbin, 2·4 ohms (brush to brush); speed of machine, 1,600 revolutions; E.M.F. of five lamps, 233·1 volts; ditto of machine, 37·8 volts, or a total E.M.F. of 270·9; current, nine amperes; horse-power, 3·26.

THE EDISON SYSTEM AT BRUNN.—On the 4th inst. some of the actors of the Brunn Theatre, which is lighted by the

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Edison system, were conducted over the machine room by Mr. Francis Jehl, who carried out the work there. The party included Herr Hans Christian and Fraulein Gollinger and others. Mr. Jehl explained to them the whole process, beginning with the conversion of the coal into heat and the water into steam, how the motion of the engine was communicated to the dynamo machine, and the rotation of the armature before the field magnets produced the current. The principle of the arc light was explained by connecting two carbon pencils to the terminals of the machine, as also was that of the incandescent light. Lamps on the latter system were connected up in series and multiple arc, and the peculiarities of each method explained. The whole of Edison's system was then practically exhibited in detail and explained. It was shown how the current would heat wires, and how power could be transmitted by its agency. Lastly, some paper was soaked in potassium ferricyanide and connected with the current; it was then written upon by an iron pencil, causing decomposition of the salt, and producing a blue mark. This was much appreciated by the lady present, Fraulein Gollinger, who styled it "writing with electricity." Altogether the actors passed an interesting two hours, thanks to the kindness of Mr. Jehl.

Electric Lighting and the Ladies.—At a fancy dress ball, held at Hull recently, a lady somewhat electrified the remainder of the company by appearing with incandescent lamps arranged about her person. To quote a local contemporary:—"Small incandescent lamps were artistically introduced into the head-dress and other portions of the costume, and the electricity was supplied by a gentleman who was in attendance with a box representing a hand organ, from which were wires attached to the lamps." According to this extract it seems a matter of conjecture as to whether the source of the electricity was the gentleman in attendance or the box representing a hand organ. The fact of the matter is that the box was a bichromate battery, which, together with the lamps and fittings, had been supplied by Mr. T. Muse, an electrician of Hull. Now that "A.I.C.E." and *The Times* have discovered the somewhat careless manner in which they "rushed in" to support the claims of the lowly "super" [Should it not be superess?], whose life they discovered to be in danger at the hands of energetic and unscrupulous theatrical managers, no doubt many of the fair sex will follow the example set them at the Savoy Theatre, and again at Hull, and place electricity in the same category as rouge, pearl powder, eyebrow brushes *et hoc genus omne*. We only hope, for the sake of the ladies, that this "novelty" will not be found to have been in vogue amongst the Chinese a few thousand years ago.

"The Advance of Electricity."—This was the title of a popular lecture, delivered by a popular lecturer—Mr. W. H. Preece, F.R.S.—at Basingstoke, a day or two since. Mr. Preece, having made his audience familiar with the theoretical explanation of matter and energy, told them that electricity was usually held to be "a form of that power called energy." Passing from this, Mr. Preece alluded to electricity as the agency by which we worked telegraphs, dynamo-machines, &c. The power of electro-magnets was well illustrated by a large one being made to lift "a heavy poker, with a boy suspended," when the current was passing, whereas it was shown that it would not lift a nail when the current was disconnected from it. The rapid growth of telegraphy, the telephone, storage batteries, the use of electricity for fire alarm and railway signal purposes, the transmission of power, &c., were all brought before the audience in turn, in Mr. Preece's usual happy style. Very many experiments were carried out on the platform to illustrate the subjects referred to, the lecturer having at his disposal numerous dynamo machines, electric lamps, secondary batteries, and other apparatus. The room was lighted by Edison lamps, the current for which was supplied by two Edison dynamos driven by a Wallis and Steevens 6 h.-p. engine. Some Swan lamps and a Pilsen arc lamp were also shown, the current being supplied by accumulators lent by the Electrical Power Storage Company, of Great Winchester-street, E.C. Mr. Preece also acknowledged his indebtedness to the London and South Western Railway Company's telegraph department, and to Mr. Cooper, of the General Post Office.

Electric Lighting in London.—The Vestry of St. James's (Westminster) have adopted a report from their Electric Lighting Committee, in which it is recommended that the Metropolitan Board of Works be informed that the vestry have passed a resolution to apply for a license under the Electric Lighting Act, 1882, and, therefore, object to any provisional order being granted for an area of supply, including the whole or any part of the parish of St. James at present; but that, if the Board of Trade determine to consider the applications of the Metropolitan (Brush) Electric Light and Power Company and the Edison's Electric Light Company, the vestry submit that any draft order that may be granted should (1) take the whole parish as the area of supply; (2) provide for a continuous supply of electricity; (3) contain a provision for reducing the charges for electricity, if cost of production or distribution is lessened, or the company earn more than 10 per cent. net profit per annum; (4) the period for purchase by the local authority should be reduced to 14 years; (5) adequate safeguards should be introduced by the Board of Trade to ensure the company fulfilling their obligations.—Mr. H. L. Isaacs, surveyor to the District Board of Works for Holborn, has reported to the board that at the present moment it is not desirable that they should apply for a license or provisional order to enable them to supply electricity for lighting purposes, and he thinks that very great care will have to be exercised that, whilst avoiding on the one hand the grant of an absolute monopoly to any one of the competing electric light companies, the most stringent conditions are imposed on the companies to prevent the streets and roads from being ruthlessly interfered with, as would be the case when rival companies were empowered to serve the same district.—The Poplar District Board of Works will not apply for an order or a license, but will wait and see what private enterprise will do for them before they move in the matter.

Our Obituary for 1882.—During the past year we have had to chronicle the following losses which electrical science and applied electricity have sustained at the hand of death. Taking the names in alphabetical order we come first to (1.) Thomas B. Ascough, of the Postal Telegraph Department. He was originally connected with the Universal Private Telegraph Company. (2.) Antoine Breguet, the well-known French electrician. (3.) Professor Henry Draper, a distinguished scientist of New York. (4.) A. J. Hare, superintendent of the Eastern Extension Telegraph Company's station at Madras. (5.) Charles Hockin, a member of the firm of Clarke, Forde, and Co., telegraph engineers, and well known in connection with cable laying, and the British Association Unite Committee. (6.) T. W. Keats, consulting chemist to the Metropolitan Board of Works, who is also known as the author of a report on the Jablochkoff system of electric lighting. (7.) Joseph Christopher Laws, who was connected with the laying of the first Atlantic cable in 1858, and latterly occupied the position of head of the

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electrical staff at the works of the Telegraph Construction and Maintenance Company, with whom he had been connected since 1869. (8.) George Leclanché, of Paris, known all over the world as the inventor of the Leclanché battery. (9.) Joseph Liouville, a celebrated French mathematician, who also wrote on electrical science. (10.) General von Lüders, director-general of Russian telegraphs for more than fifteen years, and better known to English telegraphists in connection with the Telegraph Conference held in St. Petersburg in 1875. (11.) Thomas H. Sanger, divisional-engineer of the Telegraph Department of the General Post Office in Ireland. (12.) Carl Louis Schwendler, a native of Prussia, for some time in the employ of Messrs. Siemens and Halske, by whom he was engaged in laying several cables. He was subsequently appointed to a high position in the Indian Telegraph service. He is well known as the author of one of the best books on electrical testing that has ever been published. (13.) C. V. Walker, F.R.S., telegraphic engineer to the South Eastern Railway Company, the translator into English of De La Rive's celebrated work, the assistant of Mr. Cooke in the erection of his first telegraph wire, and the layer of the first submarine cable. He also patented many practical applications of electricity.

Improved Galvanic Battery.—The *Scientific American* illustrates and describes a battery patented by a Mr. Parkhurst in a recent number. Our contemporary says:—"In this galvanic battery the positive plate is made of zinc, in any of the well-known shapes, and is provided with a wire conductor connected with it in the ordinary way. The negative plate, which is of carbon, is placed in a porous cell and surrounded with a mixture of granulated gas retort carbon, granulated black oxide of manganese, and mild chloride of mercury, or calomel, equal parts. These materials are intimately mixed together with a small quantity of water before being placed around the negative plate. As the fluids of this battery, when in operation, are very corrosive, the upper end of the carbon is saturated with paraffin or wax, and the electrical connection is made with it by casting lead or solder around it, and attaching to it a binding screw. The porous cell is filled around the carbon to within a short distance of the top of the cell with the mixture of gas carbon, black oxide of manganese, and chloride of mercury, and the top of the cell is sealed with a cement of resin and wax, or any other insulating cement insoluble in the fluid of the battery. Two small holes are left in the cement for the admission of water or the exciting fluid, or for the escape of gas which may be generated in the porous cell. The porous cell, containing the carbon plate, the granulated carbon, and black oxide of manganese, and the chloride of mercury, as above described, is placed in a suitable jar, together with a zinc rod or plate which has been amalgamated. The exciting fluid is a saturated solution of ammonium chloride or sal ammoniac. The action of this battery is as follows:—The zinc, calomel, carbon, and manganese being all insoluble in water, there is no internal action when the circuit is open. The circuit being closed, decomposition commences. The zinc is oxidised by the water of the sal ammoniac solution forming oxide. This zinc oxide immediately reacts with the sal ammoniac (ammonium chloride), first combining with a portion of the chlorine of the latter (and displacing an equivalent of ammonia), and then combining with another portion of the sal ammoniac, forming ammonia zinc chloride, while the ammoniac becomes converted into ammonia. The hydrogen being liberated at the negative plate, unites with its equivalent of oxygen from the peroxide of manganese, reducing this to the sesquioxide, and by this union forming water. The ammonia reduces the calomel into metallic mercury and hydrochloric acid, which latter unites with the ammonia, forming ammonium chloride, to be decomposed, as above described, or this latter acid may act directly upon the zinc, thereby intensifying the action of the battery."

Electric Lighting at Berechurch Hall.—Mr. O. E. Coope, M.P., writes to *The Times* of Tuesday last, giving details of the cost of lighting his residence at Berechurch Hall by incandescence lamps. From this letter we make the following extracts:—"I engaged the services of Mr. Heaphy, C.E., of the Phœnix Fire Office, to advise me upon the matter and superintend the installation on my behalf. We examined together every different system of lighting, the result being that I determined to adopt the Swan incandescent light and the Bürgin machine, and accepted the tender of Messrs. Crompton and Co. to supply the same, after I had instructed Mr. Heaphy to draw up a regular specification and contract going into every detail, and giving me the power of rejecting any work or materials he was not perfectly satisfied with. We arranged to have 200 lights of 18 candle-power each, and four dynamo machines; the engine to be of 12 horse-power, with very sensitive governor and with tubular boiler, all leads and wires to be heavily insulated in the best possible manner, and the insulation to be rendered non-inflammable inside the rooms. They were to be embedded in the walls, and kept at least 4in. apart from each other, and 4in. from every kind of metallic substance. Every floor, every room, and, in many cases, each light to have switches to turn the current on and off, as well as a lead 'cut out' to guard against overheating of the wires. The whole has been carried out as specified, and the result has been a success that has exceeded my expectations. I will now give details as to cost:—Estimate for gas plant, buildings, and erection, £740; gas main to house, £75; laying pipes in house, £200; cutting and making good again, £50; chandeliers and brackets, &c., £268 18s.—total, £1,333 18s. Cost of electric light:—Four dynamo machines, £405; 220 Swan lamps, £55; 200 sockets for same, £10; cable, wires, switches, and cut outs, £66 4s.; cutting and making good walls and floors and incidental work, £60; engine and boiler, extra fly-wheel and belting, £300 6s.; counter shafting, £25; foundations to engine and flooring, £40; erection, laying wires, &c., and carriage, £90; buildings, £150; chandeliers and brackets, &c., £268 18s.—total, £1,470 8s. I will now estimate the annual working expenses, and, in making a comparison, I will assume that it would cost the same to manufacture 1,000 cubic feet of gas at Berechurch as it does here. Electric light—200 18-candle lamps, each working 1,150 hours per annum.—Coal at 20s. per ton, £38 10s. 1d.; engine driver at 30s. per week, £78; renewal of lamps, 153 at 5s. each, £38 5s.; depreciation 10 per cent. on cost of machinery, £74; depreciation 5 per cent. on conductors, £4. Total, £232 15s. 1d. Now, for less than half this amount of light it costs me £200 a year here (Rochetts, Brentwood), and, therefore, I am, if anything, understating the expense when I say that, had I used gas at Berechurch giving an equivalent illuminating power, it would have cost me at least £400 per annum to produce. This would show an annual saving of £167 4s. 11d. to me by using electricity. Having had twenty years' experience of lighting this house by gas—which I consider a great improvement upon any previously known method—I am only too sensible of its drawbacks, and, although I am not doing away with it here yet, I am well satisfied that I have adopted electricity at Berechurch." We may remind our readers that we described and illustrated this installation in our issue of December 2.

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THE EARTH A GREAT MAGNET.—This was the title of a lecture delivered by Professor Silvanus P. Thompson at Glasgow a few days ago, under the auspices of the Glasgow Science Lecture Association. Sir William Collins presided, and amongst other scientific gentlemen present was Sir William Thomson. Professor Thompson traced the history of magnetism from the time of Dr. Wm. Gilbert, one of the physicians of Queen Elizabeth, by whom it was raised from the region of superstition and fable to that of true science, remarking that in Gilbert's book he had found the title of his address, "The Earth a Great Magnet." He proceeded to show, by experiment, the properties of the loadstone, of the magnet, and of the mariner's compass, and pointed out the various modes in which a magnet might be formed. He illustrated the declination of the magnetic needle, and explained the difference between the magnetic and geographical poles. The magnetic pole, he stated, was at present near Boothia Felix, more than a thousand miles to the west of the geographical pole. In 1657 the position of the needle showed the magnetic pole to be due north. It had been eastward before that. It then began to point westward, and the westward variation increased till 1816, when the maximum was attained. It had since steadily diminished, and in 1976 it would again point to the true north. The changes which had been observed, not only in the direction, but in the strength of the earth's magnetism, showed that the same causes which originally magnetised the earth were still at work. Strangely enough these changes did not occur at long intervals in the course of centuries, but were going on from day to day, from week to week, and from year to year. This was illustrated by those magnetic storms which interrupted telegraph operations, rang telephones, and, as was reported lately, kept one of Edison's lamps alight, though he would have liked to have seen it. These magnetic storms were most frequent in the month of May and fewest in June, again reaching their maximum about October. It had also been observed that the more violent the magnetic storms the more numerous were the spots on the sun, and the more brilliant were the auroral displays around the poles. The phenomena of the aurora were among the mysteries of science of which no explanation had been given; but it was certain that the aurora was an electrical discharge passing from the equatorial regions through the upper air, and descending at the poles, where a condensation of vapour was continually taking place. The earth was thus continually surrounded by electricity, and here, he thought, was to be found the answer to the question how did the earth become a magnet. That it was not always a magnet he regarded as certain, seeing that there were good geological grounds for believing that it was once a molten mass, and that nothing destroyed magnetism like heat. Faraday had found that by taking a bar of iron, spinning it on its axis, and carrying a current of electricity round it from the centre to the poles, a magnet was formed. As therefore there was a current of electricity continually flowing from the equatorial regions to the poles and returning again to the equator, he put forward as a guess that in this way the earth revolving continually on its axis had been converted into a magnet. This theory, of course, involved that the magnetism of the earth had been growing, was growing, and would continue to grow.

THE SEPARATION OF METALS BY ELECTROLYSIS.—This is an abstract of a paper by V. Francken, which appeared in the *Chemical News*, and relates to the processes of Claesson and Reis. The abstract, as under, is taken from the December number of the *Journal* of the Chemical Society:—"To obtain accurate results the methods recommended must be carried out most exactly. For the determination of cobalt an excess of neutral potassium oxalate must be added, but as the oxalate is gradually decomposed by the current, cobalt carbonate is deposited with the metal; this precipitate must be removed by cautious addition of oxalic or sulphuric acid. The deposition of the metal is, however, more rapid if ammonium oxalate replaces the potassium salt, but no more should be added than is necessary to form the soluble double salt. There is deposited with the metal a red insoluble oxide which is but slowly reduced; to prevent this, the liquid to which an excess of oxalate has been added is heated, and a further addition of 3—4 grams of solid salt is made. The cobalt forms a grey adhesive coating, which must be well washed with water, alcohol, and ether, and then dried at 100 degrees. Nickel is estimated in a similar manner. In the determination of iron, the chloride or sulphate, with excess of ammonium oxalate, may be used, and in the reduced state it does not readily oxidise. Zinc, separated as above, adheres firmly to the electrode, and cannot be removed by dilute acids, but can be detached by heating the capsule to redness, and treating the residue with fresh acid. The precipitation of manganese is complete only when but little nitric acid is used; the presence of potassium oxalate causes separation of the peroxide, and this oxide is not firmly attached to the electrode, so that it must be separated by filtration, and converted by heat into $Mn_3 O_4$. Ammonium oxalate must be added to bismuth nitrate solution, but some peroxide is formed which is but slowly reduced; great care in removing all water by alcohol and ether must be exercised, so as to prevent oxidation. The electrolytic deposition of lead cannot be recommended. Copper separates from an ammonium oxalate solution with great ease and accuracy. Cadmium forms a grey coating, which, although not adhering firmly, can be removed without loss if washed cautiously. Tin separates from the solution of chloride or oxalate as a fine grey coating, antimony separates as a fine light grey firmly adhering precipitate from solutions to which sulphuretted hydrogen has been added. If the solution be acid, ammonia, or ammonium sulphide in excess, is added. Ammonium sulphate accelerates the reduction. Arsenic cannot be separated quantitatively. Iron and manganese can only be separated if the formation of the manganese peroxide is prevented until the greater part of the iron has been precipitated. The presence of ammonium oxalate affects this result. If the oxalate has been decomposed before the end of the precipitation, and this is shown by the formation of a pink colour, heat must be applied, and three to four grams of oxalate added. If the quantity of manganese is small, it appears as peroxide at the positive electrode, but if the proportion of manganese is double that of the iron, then the peroxide must be dissolved in oxalic acid, without interruption of the current, so as to effect complete separation. The precipitation of manganese from the solution of oxalate as peroxide is not quantitative, therefore the liquid holding the greater part of the manganese peroxide in suspension must be boiled so as to decompose the ammonium carbonate, and then neutralised with nitric acid, after which the metal must be precipitated as sulphide. Iron and alumina are separated so long as the ammonium oxalate is in excess of the carbonate formed by electrolysis; as in the previous cases an excess of oxalate (three grams per 0·1 gram oxide) is added to the solution of the double oxalates, and the mixture is electrolysed whilst hot. If the alumina is in excess of the iron, the same precautions must be taken as in the case of manganese."

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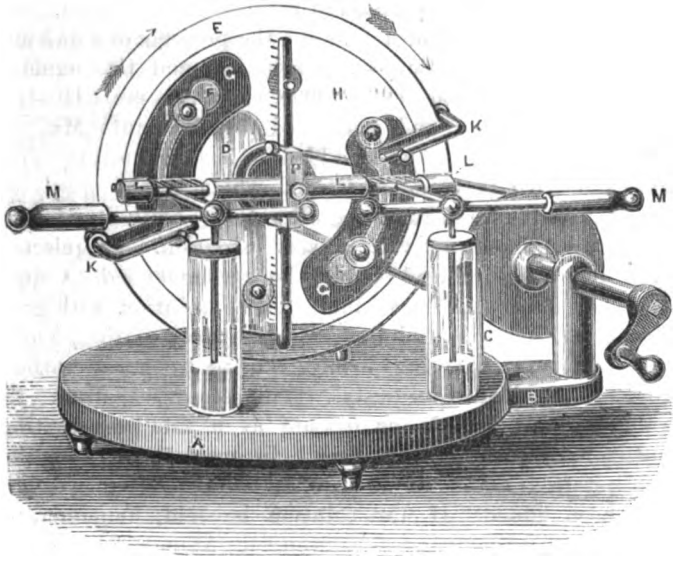
THE VOSS INDUCTION MACHINE.

BY J. T. SPRAGUE.

This machine unites great simplicity of construction with high efficiency, generating high tension electricity with less expenditure of power than other machines. It is claimed that its action is independent of atmospheric conditions, but my own experience is that while not so much affected by damp air as most others, it requires a dry air to work satisfactorily. The figure shows a very simple construction, which generates four-inch sparks at a sufficient rate to illuminate vacuum tubes steadily, and to maintain the appearance of a continuous stream of fire.

The base A carries a sliding bar, B, on which the driving wheel is mounted, so that the tension of the driving cord is easily controlled. The fixed plate of thin glass E is 12½in. in diameter, with a central opening of 3in., and has fixed upon its further side two pairs of tin foil discs connected by a strip of foil. These discs F F are covered by paper shields G G, which serve as collectors from the surface of glass covered by them. This plate, which forms the field or inductive system analogous to the field magnets of dynamo machines, is supported by two ebonite studs upon the base, and an ebonite rod entering into the central opening. This rod is fixed into a wooden pillar D, firmly secured to the



base, and a little below it is fixed a conical axis which carries the moving system and the collectors. The moving plate H, which answers to the armature of the dynamo machine, is of 10¼in. diameter, and at six equidistant points of a circle of 7½in. diameter are fixed inch discs of foil, upon the middle of each of which there is cemented a metal button, rising ⅛in. from the surface. These discs *i i* correspond to those of the fixed plate. The plate is mounted upon a tube, by means of an ebonite flanged screw and nut. The tube carries a driving pulley at the other end, and is bored to fit the axis, and secured upon it in place by a broad brass nut, screwed on the axis, which projects further to carry the collecting system. This consists of an ebonite rod, L, which is held horizontal by means of the axis, and two steel pins on the face of the nut. At each end is a brass T piece, carrying a collecting comb, and on the other arm a ball, which carries the discharging rod M, and is supported by a small Leyden jar, N. These two jars are connected together at the outer coatings by the metal saucers, which are united by a wire on the lower side of the base. I think this arrangement is open to improvement by supporting the arms with insulating pillars, and insulating the jars. In fact, one jar, with its coatings connected to the arms, would be sufficient in that case. As it is the jars make "earth" at the middle of the scale of potential of the machine, which is undesirable for many purposes.

The whole of the glass surfaces should be warmed and carefully varnished, so as to resist the deposit of moisture; and, when worked, all dust should be removed.

A second pair of combs, shown vertical, are attached to a brass frame, P, also placed on the axis, and secured there by a knob of ebonite screwed upon the end. These combs have fine wire brushes in their middles, which touch the buttons and short circuit the discs so as to discharge them just as they leave the paper shields, over the ends of which this zero comb should be placed. K K are bent arms of metal, attached by clamps to the fixed plate, and connected by strips of foil to the nearest foil disc. These arms carry fine metal brushes, which are adjusted to touch the buttons on the moving plate at the instant they face the foils on the fixed plate, so as to close a circuit at that moment, and enable the mutual reactions and accumulations to take place. As in dynamo machines, there is always some trace of residual charge, and successive inductions and transfers accumulate this, till the limit of the machine is reached, when the electricity flows into the external circuit, accumulating in the jars, and giving off in sparks proportioned to the space between the discharging balls.

The only defect of the machine is a tendency to self-reversal, which is apt to occur at a stoppage. It can be produced when desired by holding a metal point to the + brush K. The two derived inductive circuits are beautifully manifested when this machine is worked in the dark. A stream of fire is seen pouring towards the collecting comb L, on whichever side of the machine is +. If the discharging balls are set near to each other, so as to reduce the resistance of the external circuit to a minimum, this light at the + collecting comb is very brilliant; but as the balls are drawn further apart, the light there diminishes, and is transferred to the comb on the zero pair P.

I have connected the machine to a delicate galvanometer, by means of a third discharging ball, and I found when the balls were in contact, a current was generated of ampere ·00004 (50deg.). With opening of a quarter inch the current instantly fell to 10deg. (ampere ·00005). But as this interval was increased the deflection increased also, and when it became too great for sparks, and only a hissing discharge occurred, the deflection had risen to 45deg. I found the current developed was regularly proportioned to the rate of rotation, but how far this is due to variation of E.M.F. or of resistance, I had not the means of ascertaining. I also found that my observations as to current were useless as to endeavouring to make them accurate, because my galvanometer was deflected with only one terminal connected; either through the "earth" connection referred to, or else by direct induction, a circuit is completed whether it is desired or not. But my galvanometer was not intended for such treatment, having been made with a series of exchangeable coils for use with the Wheatstone bridge. The coil in use was one of 350 ohms resistance.

The machine produces beautiful brush and star discharges when the − ball is removed; if the + ball is removed there is no brush, but a violet star on the point. Ozone is freely produced while working.

An interesting experiment is to open the discharger balls about 2in., and tie a piece of soft thread across loosely; the thread is at once attracted up close to the balls, then strong attraction for the opposite portions draws the thread tightly up and instantly forms the loose parts into a loop which stands over the thread, occasionally approaching the + ball. If the loop is loose enough, it will be drawn out into an ellipse. With this thread sparks will pass over a distance which would prevent discharge without it. If the thread is cut across the middle its ends draw up and cling together long after the working is stopped.

I took the opportunity of testing the action on flame, as to which Mr. Johnstone wrote so strongly some time since, with results, as I expected, very different from his. I used a benzoline sponge lamp made of metal and stood between the balls. Of course, the flame tended towards the − ball, as though blown over from the +, while the lamp was insulated, but, if a connection was made to it from either pole, the flame was attracted to the other pole, provided the machine were worked gently. But this is overcome by a very singular

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phenomenon when the motion is increased. When the lamp is connected to +, the flame pours down the stem in a regular bubbling cascade, while the supply of spirit increases largely, and very soon the light is fairly carried away from the wick, and goes out. I purpose examining this action with appliances adapted to the purpose as soon as I have leisure.

CURRENT ENERGY.—I.

BY OLIVER HEAVISIDE.

As we remarked towards the close of Art. III. ("Magnetic Force and Current," p. 177 *ante*), if we adopt Ampère's theory of magnetism, and substitute for every magnetised particle a closed current flowing round it, we may do away with free magnetism, or imaginary magnetic matter, and have nothing but electric currents to deal with. It is, indeed, not necessary to introduce magnetism at all. We did that in order to reach the definition of a unit current in the electro-magnetic system, which is based upon that of a unit magnetic pole. We might, for example, obtain an equivalent result from the mechanical force between the terminations of two long solenoids, which varies inversely as the square of the distance, or in various other ways.

We found that the magnetic force of a small plane closed current could be derived from a scalar potential, that the force was what would be produced by equal quantities of positive and negative matter very close together, in fact supposed to be indefinitely near each other, the quantity of matter being at the same time indefinitely great, but so that the product of the quantity into the distance was finite. If magnets were unknown, this matter would be certainly purely imaginary, quite as much so as the matter which, quite similarly, would give rise to a scalar potential, whose derivatives would express the vector-potential of electric currents in space where there was no magnetic force, or, to come nearer home, the matter whose potential derivatives express the electric force wherever it has no curl, which last matter is the imaginary matter of free electricity. The fact that magnets exist does not make the magnetism any the more real, considered merely as a self-repulsive substance existing wholly on the surface of a solenoidal magnet, and also within its substance when not solenoidal; and the same may be said of the electricity once supposed to reside upon the surface of conductors.

But it happens to be a considerable assistance to make use of the idea of magnetism (or of magnetic polarisation, which comes to the same thing) in reasoning regarding electric currents, and it is particularly useful when we are considering the energy of currents. In fact, it would certainly be employed for this purpose were magnetisation unknown (presuming that this would not involve the non-existence of current) in the form of a magnetic shell, for the idea presents itself in a perfectly natural manner.

Suppose we have a current circulating in a closed path of any form, which we may, when we do not want to go into the space occupied by the current, regard simply as a closed curve. Such a current is a linear closed current. Let C be the strength of current. If we join any two points of the circuit by means of another line, and let the same current C go both up it and down it at the same time, we form two closed circuits both with equal currents of strength, C flowing round them, with the same direction of rotation as regards lines drawn through the original closed curve, which lines we may reckon to be positively directed when the current flows round them righthandedly. Now, since the two circuits have a portion of their length in common, in which equal currents are oppositely directed, there can be no change in the magnetic action at all; hence, the two closed currents, when taken together, are exactly equivalent to the original one.

Therefore, by the same reasoning as was employed in the demonstration of Theorem II., p. 56, if we suppose the original circuit to be the boundary of a surface S, and we divide this surface into an indefinitely great number of small elements of area dS, and let the same current C flow round the boundary of every one of those elements with the same direction of rotation, we know that the whole collection of small closed currents produces identically the same field of magnetic force as the single current C flowing round the boundary of the whole. The form of the surface is quite indifferent; the essential circumstance is that it must be bounded by the real current.

Now, we found (see p. 177) that the magnetic force of a current C circulating round the boundary of a small area dS was the same as that due to charges of magnetism of amounts $m\,d$S and $-m\,d$S placed on opposite sides of dS at the small distance dz apart, the axis of z being that of the current; that is to say, z is the normal to dS. The condition connecting m and C is that $m\,dz = $ C, or magnetic moment of magnet = that of the current (per unit of area, here).

Let the surface of every one of the small-closed circuits we have imagined to replace the real circuit be similarly covered with magnetism on its two faces, according to the same rule. This is equivalent to covering the complete surface S to surface density m on one side and $-m$ on the other, with the condition $m\,dz = $ C everywhere; $m\,dz$, the magnetic moment per unit area, is called the Strength of the shell. The thickness of the shell must be indefinitely little, but it need not be constant. If it vary, m must vary inversely, so as to keep the strength constantly = C. The magnetic force of this shell and that of a current C round its edge are identical everywhere, except in the shell itself.

Now, since the mechanical action between a magnet and a small closed current is the same as that between the magnet and a small magnet of the same moment as the current, similarly placed, and since we may build up any closed linear current by putting together an immense number of such little closed currents, it follows that the mechanical action between a magnet and any linear current is the same as that between the magnet and an equivalent magnetic shell. But the magnet may itself be a second magnetic shell, and since we may substitute for it a current round its edge, it follows that the mechanical action between two closed currents is the same as that between two magnetic shells whose edges are bounded by the currents, and of numerically the same strength as the latter. And the mutual potential energy of the two currents must be the same as that of the shells, which may be found from the distribution of the magnetic matter.

Now, we found (p. 177) the magnetic potential of an element dS of a shell of strength C to be $\Omega = -\mathrm{C}\,d\mathrm{S}\,\frac{dr^{-1}}{dz}$ (now employing the common definition of unit pole), where r is the vector drawn from dS to the point Q where Ω is measured, and z the normal to dS. The differentiation in the above is performed at Q. If we perform it at dS, we must write $\Omega = +\mathrm{C}\,d\mathrm{S}\,\frac{dr^{-1}}{dz}$; because if $\frac{1}{r}$ decreases when dS is fixed and Q is shifted in direction z, it increases when Q is fixed and dS shifted in the same direction.

Place a magnetic pole of strength C at the point Q. Its potential at dS is $\frac{\mathrm{C}}{r}$, therefore its force at dS in the direction z is $-\mathrm{C}\frac{dr^{-1}}{dz}$, and since z is normal to dS the whole amount of force passing through dS from its $-$ to its $+$ side, due to the pole C at Q, is $-\mathrm{C}\frac{dr^{-1}}{dz}d\mathrm{S}$, the differentiation being performed at dS. But this, with sign changed, is our expression for Ω, the magnetic potential at Q of the element of the shell at dS. The same applies to every element of the shell; consequently, by summation, it follows that the magnetic potential Ω at Q of the complete shell = amount of force passing through the shell in the positive direction, due to a pole of strength $-$ C placed at Q, or in the negative direction if of strength + C. Thus, we may express Ω in terms of a solid angle, as for electric force at p. 55; thus, Ω at Q = C × solid angle subtended at Q by the edge of the shell. The magnetic potential of a current C round the edge of the shell is of course the same.

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The magnetic potential Ω must not be confounded with the vector-potential A. The curl of the latter gives the magnetic force everywhere, both within and without a current; whereas Ω is scalar, and the magnetic force $= -\nabla\Omega$, where ∇ has the same meaning as at p. 152, and this only in space where there is no current. Therefore, in currentless space only, $B = \text{curl}\, A = -\nabla\Omega$; otherwise, $B = \text{curl}\, A$, and Ω is non-existent.

Next, consider two shells of strength C_1 and C_2, and let Ω_1 and Ω_2 be their magnetic potentials. The mechanical force between them may be ascribed to the mutual actions of the magnetic matter, and calculated therefrom. To fix ideas, let the shells be circular planes. If we place them parallel to one another, upon the same axis, and so that the N. side of one is next the S. side of the other, there is attraction between them. We may call the N. face of a shell the + face, and the S. the − (N. and S. meaning north-seeking and south-seeking, as applied to a needle), so that the N. face of shell is the same as the + face of the corresponding current round its edge. The + direction through the shell or the current is from the − to the + face. The magnetic force of a closed current goes through it in the + direction; it also goes right-handedly about the current, and the current goes right-handedly about a line of force. These relations, which are sometimes puzzling to others besides beginners, are important to be remembered, for confusion will inevitably arise if we do not keep to one consistent system. In our present case the parallel shells with contrary faces next each other attract. The corresponding currents round their edges are similarly directed, so there is consistency with the fact that parallel currents attract or repel according as their directions are similar or opposed.

Since we (temporarily) ascribe the force between the shells to the attraction of matter, their mutual energy is, on this view, potential energy, and tends to decrease. If one shell be fixed, and the other move through a distance dz parallel to itself, and F be the mechanical force in the direction of motion, the work done by the force is $F\,dz$. This is also the reduction in the amount of potential energy; or $-dM$, if M be the mutual energy. Therefore, $F = -\frac{dM}{dz}$ is the expression for the force. This is, in the case considered, a real force in the dynamical sense, viz., acceleration of momentum. But we may give an extended meaning to the term force (and this is important in the theory of energy). Let dz indicate *any* displacement, and $-dM$ the corresponding fall in the potential energy, then $F = -\frac{dM}{dz}$ is the "force" in the generalised sense, so that "force" × displacement always equals the decrease of potential energy during the displacement.

The two shells with contrary faces nearest, would attract each other from an infinite distance, and their potential energy would decrease all the time; hence, if the energy be taken = 0 at an infinite distance, where the force is evanescent, the energy is negative at any finite distance, and becomes more and more negative as the shells approach. Turn one of them round, so that similar faces are nearest; the potential energy is now positive, the amount of work done in turning the shell round being the whole increase of energy. (Rigid magnetisation supposed.) Similar remarks apply to the currents round the edges of the shells, but we have not under consideration at present what becomes of energy added to the system by externally performed work.

The mutual energy of two shells or currents admits of tolerably simple expression by means of the theorem connecting line and surface integrals. If a charge m of magnetism be brought from an infinite distance to a place in a magnetic field where the potential is Ω, the work done against the repulsion is $m\Omega$, which is consequently the potential energy of m with respect to the field in which it is placed.

Apply this to a shell placed in the field of a second shell. Let dS be an element of area of the first shell, of strength C, and dz its thickness, z being, therefore, the normal at dS. On the + face there is magnetism to the amount $m\,dS = \frac{C}{dz}\,dS$. Let Ω' be the magnetic potential of the second shell there. The energy of $m\,dS$ with respect to the second shell is then $\frac{C}{dz}\Omega'\,dS$. Now, Ω' becomes $\Omega' - \frac{d\Omega'}{dz}\,dz$ when we pass through dS to the other side, where there is a quantity $-\frac{C}{dz}\,dS$ of magnetism, whose energy with respect to the second shell is, therefore, $-\frac{C}{dz}\,dS\left(\Omega' - \frac{d\Omega'}{dz}\,dz\right)$. The energy of the combination is the sum of the separate energies of the two charges of magnetism, that is, $C\,dS\,\frac{d\Omega'}{dz}$.

But $\frac{d\Omega'}{dz}$ is the magnetic force at dS of the second shell in the direction of the normal from the positive to the negative side; therefore, $dS\,\frac{d\Omega'}{dz}$ is the amount of magnetic force arising from the second shell which passes through dS in the negative direction. The same is true for all areas in the first shell; hence, by summing up, we find that the energy of the first shell with respect to the second = strength of first shell × total amount of magnetic force passing through it in the negative direction arising from the second shell. Or, if M denote the energy, and we always reckon the force in the + direction through a shell,

$M = -C \times$ amount of mag. force through C due to C′. (1),

if C′ is the strength of the second shell. Similarly, by starting with the second shell, we find

$M = -C' \times$ amount of force through C′ due to C . (2).

[It is customary to speak of the "number of lines" of force, each line being the representative of a definite "amount" of force, or "surface-integral" of force, to use the mathematical expression. But no-one speaks of the "number of lines" of current passing through a surface; the expression "amount" or "quantity" would be rather used. Fractional parts of a line of force are awkward, but there is no such difficulty with amount or quantity. On the other hand, "surface-integral" is rather too scientific.]

The right hand members of equations (1) and (2) are identically equal, and a remarkable reciprocal property of closed currents or shells is disclosed. Make the currents each unity; then it follows that the unit current in the first circuit sends the same amount of force through the second as the unit current in the second circuit sends through the first, whatever may be the form or relative position of the circuits.

Equation (1) does not apply merely to the field of a shell or single circuit. By the manner of its derivation it applies to any magnetic field whatsoever produced by magnets or currents, substituting for "due to C′" the expression "due to the field." This is to exclude the magnetic force of the current C itself.

Equations (1) and (2) may be immediately put in another form. The magnetic force of a current is the curl of its vector-potential, therefore (by Theorem II., p. 56) the amount of magnetic force through any circuit = line-integral once round it of the vector-potential, whose curl is the force considered. So let A and A′ be the vector-potentials of C and C′, then (1) and (2) become

$M = -C' \times$ line-integral of A once round C′ . . (3)

$= -C \times$ line-integral of A′ once round C . . (4)

These, again, may be put in another form, which will be useful. Consider (3) only. Let ds' be an element of length of the current C′. The portion of M due to it alone is $-A\,C'\,ds'\cos(A\,C')$, or simply $-\overline{AC'}\,ds'$, (if we place a stroke over the product of two vector quantities to signify that the product of their magnitudes (disregarding directions) is to be multiplied by the cosine of the angle between their directions, *i.e.*, A multiplied by component of C′ along A, or C′ multiplied by component of A along C′; as will be done hereafter). But A is itself a line-integral, viz., once round the current C. Let ds be an element of length of C, then the portion of A contributed by it is (by

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the definition of vector-potential) $+ \frac{C}{r} ds$ at a point distance r from C, and its direction is parallel to C. Therefore the portion of M due to the pair of elements C ds and C′ ds' is

$$-\frac{1}{r} CC' \cos(CC')\, ds\, ds' \text{ or } -\frac{1}{r} \overline{CC'}\, ds\, ds' \quad . \quad . \quad . \quad . \quad (5)$$

and the complete energy is the sum of all such terms, so as to include the whole of both currents, *i.e.*,

$$M = -CC' \iint \frac{\cos \epsilon}{r} ds\, ds' \quad . \quad . \quad . \quad (6),$$

where r is the distance between ds and ds' and ϵ the angle between their directions, and the integration extends once round each circuit, the direction chosen being that of the current in each case. (6) is the simplest form of Neumann's formula.

With respect to (5) and (6), the latter, referring as it does to closed circuits, is exact; but as regards the former all we can say at present is that the potential energy of two closed currents is the same *as if* a pair of linear elements, one taken from the first circuit, the other from the second, possessed the mutual energy expressed in (5), for such elements could not exist alone.

ELECTRICAL ACCUMULATORS OR SECONDARY BATTERIES.*

BY PROFESSOR OLIVER LODGE.

No. X.

Having charged the cell and allowed it to stand idle for a time it only remains to discharge it.

The regular and normal operation of discharge would be as follows:—We start with the opposing surfaces—spongy, hydrogenised lead on the one side, and peroxide, more or less saturated with oxygen, on the other—as near together as they can ever be, and with a highly-conducting, strongly acid liquid in the narrow space between. An initial current of great vigour is, therefore, produced, and any spare oxygen is probably at once consumed. The current continues, with hardly diminished intensity, until the surface hydrogen has also disappeared, and a scum of sulphate forms on the negative plate. This is the first thing that causes any serious weakening of the current; only it must be remembered that it acts by increasing the internal resistance, not by diminishing the electromotive force to any important extent, and hence, that it may considerably reduce the strength of a powerful current, although a test with an electrometer or high resistance volt-meter might not show any marked deterioration. The more powerful the current demanded, the more is the resistance offered by this scum of consequence, and, moreover, the sooner does the scum form; and this is mainly why a cell refuses to give a very strong current for many minutes together.

On allowing the cell to stand the scum clears off, and the original power is to a great extent restored. And there is to be noticed about the scum, that the faster it is formed the faster it clears off. If it is formed very rapidly by a very powerful current, the cell need not stand long to recover itself; but if it only forms after a long continuance of a weak current, it is much more permanent, and a long period is necessary for recovery.

The scum always takes longer to clear off than to form, but the two times are not greatly different. The clearing away of the insulating film is due, I believe, to the local action between the hydrogenised lead in the deeper layers of the coating and the dehydrogenised lead of the surface; and if this is so, there must come a time when the film will refuse to clear off, and a permanent increase in the internal resistance will set in, increasing as the action penetrates deeper and deeper into the negative coat until the still metallic lead can only be reached by penetrating through a surface layer of non-conducting matter, consisting mainly of sulphate, but also partly, I think, of the lower oxides of lead.

Messrs. Gladstone and Tribe have made the remarkable observation that patches of *peroxide* form on the — plate during the discharge. The fact has not come under my own notice, as I was so totally unprepared for any such phenomenon that I never looked for it. However, as Messrs. Gladstone and Tribe have detected it by chemical analysis, we must accept the fact, unexpected as it is; and certainly a film of such a substance on the negative plate will account for any amount of falling off of the cell, down to complete stoppage, by reason of its high opposition electromotive force. Moreover, it is certain that local action would speedily clear away such a deposit, and hence, given such a film as this, the loss of power and recuperation of the cell are accounted for in the fullest and most satisfactory manner.

Any difficulty which one feels in perceiving how the peroxide comes to form on the plate during discharge, of course only exists when the cells are discharged separately. When a number of cells are discharged in series, as is common, it is the simplest thing in the world for those which get empty first to begin to charge up in the reverse direction by the current from the others; and the current from a set of cells will therefore cease, not when all are discharged completely, but when the opposition electromotive force of the worst cells becomes equal to the remaining electromotive force of the best. Then allowing the cells to stand a bit, the worst cells will lose rapidly their opposition electromotive force, and accordingly the set will have picked up again and give a residual charge, until the electromotive forces balance again; and so on alternately, the action being precisely analogous in every respect to the residual charge of a Leyden jar with a stratified dielectric, as worked out by Maxwell. But, as Kohlrausch pointed out, to get *Nachwirkung* it is not essential to have a stratified dielectric, so with secondary batteries. A single cell will give it, though not to the same extent as a series.

It is obvious that all these actions are very objectionable, and not at all what is wanted in practice; but as long as cells are not all identical, a series must give these effects in a very marked degree. If it is impossible to make cells really alike, therefore the best plan is to make them as best you can, and then test them and sort them out into qualities, putting all of the same sort together, where they will work much better and more steadily than if mixed with others either better or worse.

A certain percentage will naturally be found exceedingly good; and these, also quite naturally, may be selected for important occasions, such as crossing the Channel.

And now what about the positive plate during discharge. In the normal operation the front layer of peroxide will get reduced to a lower oxide, apparently the yellow oxide litharge, and much of this will be then turned into sulphate by the acid. After this action has gone on for some time the internal resistance of the cell must have increased by reason of the non-conducting layer of lower oxides and of sulphate which intervenes between the active layer of the peroxide and the main body of the liquid.

I apprehend that all reduction of this kind is permanent, and that no recuperative chemical changes go on at this plate when the current is interrupted. Nevertheless, it is a certain fact that the power of the + plate too does fall off temporarily while producing a current and pick up again when standing idle, though not, I think, to the same extent nor so soon as the power of the — plate does; in fact, for a long time the fall and rise is not much noticed, but it is most apparent when the active layer is buried at some depth beneath the clogging and non-conducting products of reduction. The cause of the loss of power in this case, I therefore think, is solely due to the exhaustion of the acid inside the porous mass as it combines with the protoxide formed; and the rise of power is due to the renewing of the strength of the acid by diffusion from the main body of the liquid.

If only a weak current is demanded from the cell, the diffusion may be rapid enough to keep the acid fairly strong, and no alteration of power need be noticed, but with a powerful current at intervals the alterations are more marked.

Mr. Bosanquet says that with some secondary cells made by him the alternations of power were so marked and so extremely rapid as to cause the carbons of his lamp to chatter. I venture to doubt whether anything like this rate of recuperation is possible, and I have known lamp carbons to chatter when supplied simply from a dynamo.

After the cell has been discharged slowly for a long time, with intervals for refreshment if necessary, it ultimately is quite exhausted. What has given out, the + plate, the — plate, or the acid? I think that in many cases the acid is the first to be consumed, and that further life might be given to the cell by changing the liquid, but of course this depends altogether on the roominess of the cells. The + plate may be usually the first to fail in a large cell, by reason mainly of the local action spoken of in the last article, which reduces, and, worse still, detaches, great portions of peroxide of lead. For this local action goes on uninterruptedly, though slowly, it must be remembered, whether the cell is producing a useful current, or whether it is standing idle; and a lapse of time is as deleterious to the + plate in one case as in the other. Still there are individual + plates which appear to resist this action much better than others, though for what reason it is hard to say. The — plate will probably last the

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longest, though its active surface may ultimately get so crusted over as to be of comparatively little use.

I have spoken so far of the normal or theoretical discharge of the cell, but in practice it is no more easy to get the active layers to recede steadily from the front of the coatings to the back than it is to get them to advance steadily in the charging operation. On the whole, however, I think the irregularities during discharge are less marked than during charge, and that there is not the same likelihood for protuberances and excrescences of action to extend from the front to the back as from the back to the front, and this obviously because the one case is analogous to stable and the other to unstable equilibrium. In the ordinary use of an ordinary cell the plate is eaten away with fair uniformity unless it contains foreign metals; but in electro-depositing a metal any little excrescence gets magnified, and a rough and hillocky deposit is the easiest to produce.

The irregularity we have to look for during discharge, therefore, is simply isolation of portions of the coatings on a minute scale; so that, for instance, on the + plate particles of peroxide instead of being reduced may be reduced *round*, and being thus isolated from conducting communication with the + plate, must remain unchanged and useless. In this way grains of particles of peroxide remain mixed up with the reduced matter on the + plate to so great an extent that the reduction of the plate barely changes its colour. The litharge and sulphate formed do give the plate a lighter aspect, but so very large is the proportion of unaltered black peroxide mixed up with them that an unpractised eye could not tell by looking at it whether a layer of peroxide were "reduced" or not.

The same may be said to a less extent of the — plate, where a large proportion of metallic lead remains in isolated specks uniformly and abundantly distributed through the mass of sulphate and oxide, or whatever the rest of the lead has become changed into.

It must be understood that these detached particles, whether of lead or of peroxide, are of no use whatever, and that they simply act as a clogging obstruction to the current as well as to diffusion, for, though themselves conducting, they conduct to nowhere, and no current would think of making use of mere isolated specks of conducting matter lying in its path, but would go round and between them just as carefully as if they consisted of glass dust.

It is for this reason that nothing at all comparable to the quantity of electricity required to form a cell originally can ever subsequently be got out of it. This of itself is not of such pressing importance—except, indeed, where *weight* is a fatal objection; it would be sufficient in practice if all that was put into a cell when re-charging could be got out during the discharge. Unfortunately this also is not possible.

Still the difference between a charge quantity and a discharge quantity is not anything like so great as that between the original form quantity and a subsequent either charge or discharge; and if one were to discharge cells singly, and give them plenty of time, I see no reason why a very large percentage of the charge current should not come out of them. There would necessarily be *some* difference, by reason of the evolution of oxygen during charge, all this being irreversible action; but the amount of this may be kept pretty low. From a series of cells discharged together, however, there will often be a striking difference between the charge and the discharge, as already explained, simply because the cells may not be precisely alike.

Again, if the cells are discharged too rapidly, they can hardly be expected to give the same quantity as if discharged more nearly at the same rate at which they were charged. At the same time, I have not many numbers bearing on this point, and the inquiry is complicated by the periods that must be allowed for refreshment when strong currents are wanted.

The number of ampere hours a cell can give out, however, is not the really important matter. We must ask also at what electromotive force does it give them out? The cell should be discharged through an integrating ergometer to give a real measure of what it can do, not through a voltameter or galvanometer; and we should thus find a sad discrepancy between the work put into any cell with which I am acquainted and the work taken out. For the cell during charge is always at its best, and its electromotive force is high; but, during discharge the electromotive force gradually falls, until the last portions of current are leaked out of the cell with a miserable remnant of force which accomplishes nothing. It is as if we stored energy in a tall cistern, pumping the water in at the top and drawing it off at the bottom. If the cistern leaks there is an obvious loss of power; but, even supposing it perfectly water tight, so that the discharge quantity is equal to the charge quantity, nevertheless there will be a deplorable difference between the work required to pump it in, all at the top, and the work obtained at the bottom from the gradually failing head of water.

It is fortunately not quite as bad as this with a Faure cell. It is more as if the supply pipe entered the tank somewhere near the middle, while the exit pipe left at the bottom. Thus we should be pumping in the first half of the charge against about half the maximum electromotive force, and the second half against a gradually increasing force. The discharge electromotive force would be a continually decreasing one as before. This analogy, however, is rather too favourable; for it makes the initial electromotive force of the discharge equal to the final electromotive force of the charge—which is not the case. The closest analogy would be to suppose the supply pipe to be supported on a float at a height above the water equal to one-third the total height of the tank, and to rise with the level of the water, so that it is supplied at a pressure always one-third greater than that at which it is drawn off. To complete the analogy, the cistern must be supposed to leak slowly, so as to empty itself by long standing; and if it had an elastic and porous membrane stretched across it, some analogy to the failure of the cell to give a powerful current for long together, and to its recuperation when let alone, would be observed.

I have supposed the cistern to be of uniform diameter, but it may be hoped that Faure cells are cisterns with enlarged tops, or are conical vessels with the wide end upwards like drinking glasses. The more this can be exaggerated the better; and if the bottom of the cistern could be contracted to a pipe, and the top expanded into a large shallow tray, perfection would have been reached, especially if the height of the float were but small, and if the leaks were mended.

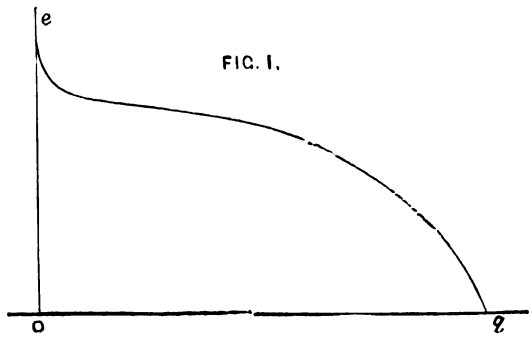

FIG. 1.

It will be understood that the reason I specify one-third of the cistern as the height at which the supply pipe is to float above the water is because the usual discharge electromotive force is 1·8 volt, and the usual charge electromotive is 2·4 volts. When you begin to charge the cell its electromotive force is less than this, and when the cells are full it is more; but 2½ volts is a good allowance per cell, the odd ·1 being sufficient to send the charging current through the resistance of the cell and connecting wires, at least when the acid has not been absorbed by long standing. And in discharge it is only at the first instant or two that you get a higher electromotive force than 1·8 volt.

By observations with an electrometer galvanometer and watch, the shape of the cistern corresponding to any given cell can be constructed; and the shape during charge can also be constructed, and its difference to that of the discharge appreciated without making use of the rough approximation of the float.

The outline of the cistern will be a curve having electromotive force—or e—as ordinates, and $\frac{dq}{de}$ as abscissæ, q being quantity of electricity given out by the cell as recorded by a voltameter, or as observed by means of a galvanometer and a watch. To understand how to draw the curve, first consider observations made with an electrometer and a voltameter, and let their indications be plotted, e for ordinates, q for abscissæ; then draw a curve with the same ordinates having as abscissæ the trig. tangent of the inclination of the tangents of the first curve to the vertical; this will be the outline required.

Fig. 1 shows the kind of appearance of the e, q curve; and Fig. 2 shows the curves e, $\frac{dq}{de}$. In the first the total quantity of electricity given out by the cell is represented by the length of the base line $O\,q$, while the area enclosed represents the energy of the discharge. In the second the area enclosed by the curve represents the quantity of electricity, and the work done by the discharge is represented by the moment of this area about $O\,X$. We may consider the curve of Fig. 2 as the outline of a cistern, or we may picture it to ourselves as a heavy horizontal plane pivoted on $O\,X$ as an axis, and consider the rotating moment which it has about $O\,X$. But, after all, Fig. 1 is the simpler curve, and it will show most instructively the relation between the work done in charging and the work obtained in discharging

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the cell. Fig. 3 shows the charge and discharge curves superposed, the charge and discharge quantities being naturally drawn in opposite directions. O P is the charge curve, the quantity of electricity put into the cell being O N, and the work of charging being the area O P N; P B is the discharge curve, the quantity given out being B N, and the useful work the area B P N. The area O P B, of course, represents the loss of energy; the efficiency of the cell is the ratio $\frac{B P N}{O P N}$.

These curves for secondary batteries are as instructive as indicator diagrams for steam engines. They are, in fact, precisely analogous to them, and it would be not difficult to construct a machine for drawing them automatically, but it would necessarily be a long operation. The beauty of the steam engine indicator is that the charge and discharge of the cylinder take place too rapidly for the operation of taking a diagram to be by

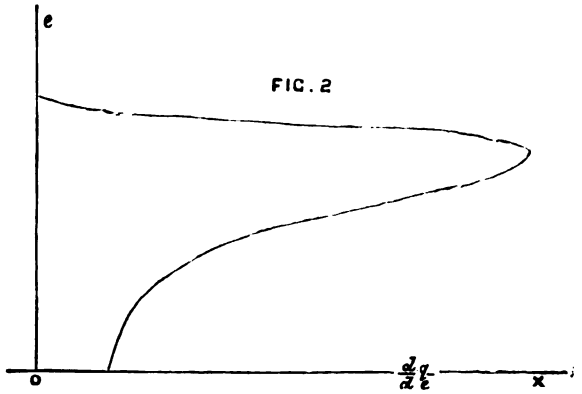

FIG. 2

any means a tedious one. The electrical indicator, however, need not in any way interfere with the practical work of the cell any more than the steam engine indicator does, and it would be most instructive to have them fitted up to cells made in various ways, so as to really learn all about their behaviour, and especially about the influence on efficiency of a lapse of time between charge and discharge.

When cells are being charged and discharged for experimental purposes only, care may be taken to keep the resistance of the circuit constant, for then the number of ampere hours *squared* does give a simple measure of the work of the cell.

I have not said much explicitly about one very important application of secondary batteries for which they seem better fitted in their present state than for actual storage by retention, viz., their use as regulators, in a branch circuit between the dynamos and lamps. The charge and discharge will then go on almost simultaneously, and the cells will, therefore, be in a high state

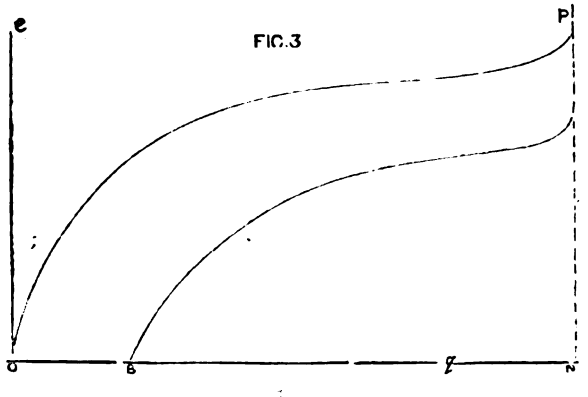

FIG. 3

of efficiency. The only danger is that the + plate may get peroxidised completely and crumble to pieces, a thing which may happen to any Faure cell if much overcharged.

For this regulating work a return to some form of the old Planté cell, with its low internal resistance, might be advisable, as great storage capacity would not be an essential unless, indeed, the cells had to insure one against an accidental breakdown of the engine or dynamo.

Again, some applications such as locomotion require light cells, and also sometimes a powerful current for a comparatively short time, such as a tramcar run. For such cases also something more like the old Planté might be useful; and in general cells for different purposes will have to be made on different plans, and an electro-store for a town will be a different thing from an electro-tank for a house, and this, again, from a little electro-box for a tricycle.

A question which naturally occurs to one on reading what I have said about the acid being sometimes the first substance to fail in the cell is—why it is not the practice to supply the cells with more acid and more space for it? The answer, I think, is, that the quantity of sulphate of lead in the coatings, and especially in the — coating, would be thereby increased, and that this sulphate of lead is very objectionable because it is so difficult to reduce. For, although Messrs. Gladstone and Tribe have shown that I was wrong in saying that sulphate of lead, by itself and as a paste, was quite incapable of reduction, yet the strength of current used by them, the time allowed, and the consequent waste of power in simply generating hydrogen gas renders it quite out of the question in practice to attempt to charge a cell whose negative plate is coated with nearly all sulphate of lead, and if an unlimited supply of fresh acid were accessible this is what the — coating would be likely, sooner or later, to become.

Another thing I want to say is that in Article No. 3, when speaking of the gas evolved from the cells while charging, I laid more stress on the hydrogen than on the oxygen. This was wrong. The gas evolved from charging cells is little else than oxygen and ozone; and if any hydrogen more than an occasional bubble or two is given off, it means either that the charging current is unnecessarily strong, or else that the cells are nearly full.

I have now concluded the present series of articles, and if it is noticed that I make no mention of the modification of Faure cells in which the coatings are supported in the interstices of cast lead gratings instead of being spread over the outer surface of plates, it is because I am dealing more with the scientific aspect of the subject than with the microscopic modifications which appear to constitute patentable improvements. What I have said about the active layer of operation during the formation of the cell remains, however, fairly true for these cast gratings, if for "back" we read portions next the lead, and for "front" portions near the centre of each hole; but that the layer of operations recedes in quite the same way during discharge I do not think likely, and it is not quite easy to see how the portion in the very middle of the holes gets acted upon during discharge. But if it does not it matters very little, as it would only remain inert ready for the next charging.

The doing away with the cloth material between the plates would seem to be an improvement, but I cannot think it safe. The risk of short circuiting, whether by dropping of substance out of the holes or by warping of the plates, is so great, and the damage done to a cell by short circuiting is so final, that some continuous insulation between the plates appears necessary, however troublesome and otherwise objectionable it may be.

Although the practical importance of secondary batteries is felt and recognised in a remarkable way at the present time——mainly, no doubt, by reason of the immense weight and enthusiasm of Sir William Thomson's opinion—and though a great deal of experience bearing on the subject from the practical point of view has now accordingly been attained, yet any one reading the "Recherches sur l'Electricité" of M. Gaston Planté, must be struck with the small advance we have made on his work, considered from the purely scientific aspect.

I had been unable to obtain a copy of this book till quite recently, and am struck on finding the whole details of the action of secondary cells worked out with such completeness and precision. He knows that the loss of power of a cell is caused by a scum on the — plate, a fact which I thought I had observed. He speaks about local action on the + plate as clearly as Messrs. Gladstone and Tribe, and he suggests that the scum on the — plate may in some cases be an extremely thin coat of peroxide—a fact which the researches of these chemists seems now to have established. Whatever future may lie before lead secondary batteries as stores of power on the large scale, the name most imperishably associated with their early development will be that of Gaston Planté.

ROYAL SOCIETY OF EDINBURGH.—At the third ordinary meeting of this society, held this week, Professor Crum Brown communicated the results of a large number of experiments made by Mr. Thomas Andrews, Assoc. M. Inst. C.E., "On the relative electro-chemical positions of wrought-iron, steels, cast metal, &c., in sea water and other solutions." Mr. Andrews found that the relative electro-chemical positions of these metals were not static, and a marked result of the observations was the steadily changing deflections noticed from the commencement, frequently resulting in a complete exchange of the electro-chemical positions of the metals. The practical deduction was that the danger from greatly increased corrosion in sea water, which the observations displayed, was not to be disregarded by the engineer in dealing with these metals.

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1882.

We had no intention of taking up part of three issues with our annual summary when we first commenced to write, but so it happens. Loose threads must be taken up, and information incorporated which had not reached us soon enough to take its proper place. We have, then, to return to the progress of electric light in 1882. The work of the

PILSEN, JOEL AND GENERAL ELECTRIC LIGHT COMPANY has been mostly preparatory. The company was registered on May 15, the share capital during that period of excitement being subscribed seven times over in three days, and the allotments made on May 23. Suitable works have been obtained at the Malden Factories, Kentish Town, and fitted up for producing the electrical apparatus manufactured by the company. Besides this preparatory work, the company has carried out installations at Messrs. Baker and Co.'s (Holborn); Messrs. Crisp and Co.'s (Seven Sisters-road); Messrs. Hopkins and Pegg's (Shoreditch); Messrs. Dewhurst's (Manchester), Messrs. Lewis and Co.'s (Liverpool). At the latter establishment 57 Pilsen arc lamps are used. Several of these lamps are also in use by the Royal Engineer Committee, Brompton Barracks, Chatham. Quite lately a contract has been signed to light the premises of the Union Society at Oxford. This will be one of the most important installations of 1883, and if the company carries it out to the satisfaction of the Oxonians there is no doubt it will lead to a large amount of work in the country mansions throughout the kingdom. From a business point of view, success here means an advertisement that could hardly be surpassed for effect anyhow or anywhere.

The NORTHERN ELECTRIC LIGHT COMPANY was the first Scotch electric light company registered, being formed in October, 1881, by a few leading local gentlemen in Dundee. It is purely a supply company, and does not manufacture. It supplies the apparatus of any manufacturer as desired, but has hitherto generally used Siemens's machines and arc lamps and Swan incandescent lamps. The work carried out has been of various kinds—arc lighting for shipbuilding yards, for dye works, for jute factories, and for paper mills; incandescent lighting for private mansions, hotels, public halls, newspaper offices, &c.; while, besides these permanent installations, a large number of temporary installations have been made for exhibitions, flower shows, bazaars, banquets, *conversaziones*, &c.

The ELECTRIC LIGHTING SUPPLY COMPANY have been principally engaged in the production of electrical fittings during the past year. Some idea of the very extended demand that has arisen for this kind of work may be gathered from the fact that they have sold upwards of 3,000 of Hedge's patent switches, besides a large number of the ordinary kind. The company's works are at York-street, Westminster, where they are also manufacturing a dynamo known as the Franklin-Bürgin, the essential parts of which are as in the ordinary Bürgin. One of these machines is working incandescent lights throughout the Victoria Mansions, and a second is to light the new restaurant. The company have a large order in process of execution for the Liverpool docks, the system of lighting which is simply an extension of the original plan of powerful arc lights suspended from the top of lattice iron poles so as to illuminate for 180 yards on every side. In order to meet the demand for carbons and battery plates, a manufactory has been started on a very large scale by the Barnsley Carbon Company at Barnsley. The carbons are made on the American plan of pressing a number at a time, and from a refuse material which resembles very closely the carbon from petroleum, to which the American carbons owe their purity. The present capacity of the works is equal to 10,000 carbons a day, the process of making taking about three weeks.

THE SWAN UNITED COMPANY.—The following is a further account of some of the work merely indicated in our previous paragraph on this company:—Ss. "Manapouri" and ss. "Wairarapa," belonging to the Union Steamship Company of New Zealand, built by Messrs. Denny Brothers, Dumbarton, were each lighted throughout with 145 Swan lamps and two differential arc lamps for temporary use while discharging cargo. The current is supplied by Siemens coupled alternate current generators, which are driven direct. The lamps were adapted to the plated and bronzed oil lamp fixtures supplied by the shipbuilders. The whole of Messrs. Coxon and Co.'s Newcastle-on-Tyne drapery establishment has been lighted. The installation consists of 46 50-candle

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lamps and 76 20-candle lamps. The lamps are suspended from plain drop pendants with ornamental bell-shaped obscured globes. The 50-candle lamps are used in the windows. There are two novelties in connection with this installation, *i.e.*, the outside reflecting lanterns, in each of which two 50-candle lamps are placed, and the illumination of air tight glass cases with obscured Swan lamps fixed inside them. The current is supplied from a Siemens alternating current machine, which is driven by a Tangye horizontal engine. Messrs. Coxon and Co. also have a Siemens direct current machine driving a 3,000-candle arc lamp at the corner of their premises, suspended outside so as not to interfere with the Swan lamps inside. The new house of T. Richardson, Esq., M.P., Kirklevington, has been fitted up with leading wires necessary for installing about 90 lamps, and the order has been received for the supply of steam engine and dynamos for completing the installation. The machines to be used are two of Siemens's S D 7 machines, which will be driven by a Robey vertical engine and boiler.

The ss. "Goorkha," of the British India Steam Navigation Company, was fitted up whilst building at Messrs. Denny's yard with 91 Swan lamps, and four arc lamps for temporary use on deck. The current is supplied from a Siemens alternate-current generator, driven direct. The lamps are fitted in the Swan Company's silver-plated globe pendants in the saloon, and on plain-plated brackets in the state rooms, and bronzed brackets in the engine rooms. The ss. "Cephalonia" and "Pavonia," Cunard Steamship Company, were each fitted throughout with 320 Swan lamps and two arc lamps for temporary deck use. The Swan lamps were fitted in the saloons into the plated oil pendants, and in the state rooms into the three-cornered oil lanterns. In other parts of the ships plain brackets and obscured globes were used, and in the engine rooms some of the lamps were made portable. The current is supplied by two Siemens alternate current machines.

The installation at Blaydon Hall, the seat of Sir M. W. Ridley, Bart., consists not only of Swan lamps, but also of motors for conveying the power of the home farm engine to other portions of the estate. Eighty lamps are installed in the house, and 15 in adjoining buildings. The house is distant 600 yards from the home farm, and the current is conveyed in underground insulated leading wires. There are two motors fixed, the one for driving a water pump, which sends water either to the house or to the home farm for use in the boiler, and another is fixed at about 300 yards distant, in a wood yard, where it drives a circular saw and an ordinary mortar mill. The dynamos and motors used are Messrs. Siemens's direct current machines, driven by the farm engine. Messrs. Rowntree, Son, and Co., Scarborough, last year completed the building of a new drapery shop, and gave orders to the Swan Company to light the building with 220 Swan lamps. Most of the lamps are supported in groups, under ornamental silvered glass reflectors, with silver-plated mountings. Other lamps are suspended by scroll brackets attached to the counter rails. The current is supplied from a Siemens alternate current generator, driven by a 16 horse-power Otto gas engine. The jerking motion of the gas engine is completely got over by the addition of a fly-wheel on the exciting dynamo, and by the use of long slack straps. An interesting feature in the installation of Morland House, the seat of Captain F. Markham, is the use of a turbine. This installation consists of 40 Swan lamps fitted throughout the house. The current is supplied from a Bürgin dynamo machine, driven by a vortex turbine supplied by Messrs. Gilkes and Co., of Kendal. Messrs. J. H. Gartside and Co., Buckton Vale Dye Works, Stalybridge: This installation will consist of about 630 Swan lamps when all are fitted up. The whole establishment will be fitted with Swan lamps, to the entire exclusion of gas. About 210 lamps are now working satisfactorily. Some portable lamps in wire guards have been supplied to enable the workmen in charge of the calico printing machines to examine minutely the fabric as it passes across the rollers. The current is supplied by three of Siemens's alternate current generators, driven by means of belting from the mill shafting. The installation at Messrs. W. F. Moore and Son's, Tromode, Isle of Man, when complete will consist of about 220 Swan lamps, and about one-half the total number of lamps installed will be fixed in the mill, and the other half between the proprietor's and manager's private residences. They will be supplied with current from two of Siemens's alternate current generators, driven by belts from the countershaft of a water wheel. All the wires, &c., are laid, but some delay has occurred in the preparation of the driving arrangements. The paddle-steamer "Lonsdale," belonging to Captain Deane, was built by Messrs. R. Steele and Co., of Greenock, under the superintendence of Mr. J. F. Spencer. She was lighted by the Swan Company with 44 Swan lamps supported on ornamental plated pendants and brackets, also supplied by the Swan Company. The current is supplied from a Siemens $S D^2$ machine, driven by a belt from a Tangye vertical engine. The dynamo is placed on a sliding bed, to enable the belt to be tightened when the machine is running. At Messrs. Webb Brothers, Randalstown, Co. Antrim, 30 Swan lamps, in various portions of this firm's linen weaving factory, are used. The power is obtained from a turbine wheel, and the dynamo machine used is Siemens's S D 7. An installation of 80 Swan lamps in the drapery establishment of Messrs. Duff and Rowntree, Bishop Auckland, has been made. The lamps are fixed in the work rooms as well as in the ware rooms. On market days and other special occasions a Weston arc lamp is used outside the premises. The current is at present supplied by a Siemens alternate current machine driven by a coupled Tangye vertical engine, but Messrs. Duff and Rowntree intend to replace this machine with a Ferranti or other machine. The ss. "Hammonia" is being fitted up for Messrs. J. and G. Thomson, of Glasgow, the builders, and is to be lighted throughout with about 100 Swan lamps. The current will be supplied from a Siemens coupled alternating-current machine, driven by means of a single belt from the fly-wheel of a Tangye vertical engine. The machine is fixed on a sliding bed, so that the belt can be tightened when the machine is running. Orders have been received for fitting up the ss. "Nerbudda," British India Steam Navigation Company, now building at Messrs. Denny's yard, with 90 Swan lamps, in a similar manner to the ss. "Goorkha." The driving power will be a similar arrangement to that adopted on the ss. "Hammonia," viz., a Tangye vertical engine, driving coupled alternating machine.

THE JABLOCHKOFF COMPANY.—During the year this light has been used at Ulverston, at the mines of Messrs. Harrison, Ainslie, and Co., giving complete satisfaction, and there is a great probability of the use of the light being extended. The Jablochkoff light has also been installed at the Cobalt mines of Sir Hussey Vivian, in Norway, and at the Newhaven Harbour extension works of the Brighton Railway Company. A large amount of work is anticipated. Some is in hand, such as that at the Gaiety Restaurant, where Messrs. Spiers and Pond will use about 30 Jablochkoff and 50 Swan lamps to light table d'hote, grill room, bar, &c. The current will be supplied from the Jablochkoff Company's new works in the Belvedere-road. We understand that the well-known Magazines du Printemps, Paris, rebuilt after a fire believed to have originated with the gas, will be lighted with 350 Jablochkoff lights, of which 150 are already fitted. We must not forget the indoor installation of Messrs. Womersley and Co., in the Poplar-road, who have the necessary apparatus for 20 lights.

We trust that the current year will be favourable to electric light work, and for the various companies embarking in this new field of enterprise.

THE INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS (SILVERTOWN).—These works, which we generally call the Silvertown Works, have been very busy during the year manufacturing and laying the West Coast of America

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cables. The manufacture of cable forms but a branch of the company's works, other branches being devoted to the manufacture of all kinds of telegraphic and electric apparatus. The company, we believe, manufacture Bright's fire alarms, a large quantity of telephonic apparatus, batteries of various kinds, a good deal of torpedo, cable, and firing apparatus, besides india rubber goods, &c. Altogether it is one of the finest establishments in the world, and is admirably conducted, every effort being taken to ensure the goods being manufactured in the best manner. To return, however, to the cable work, we cannot give the exact lengths of the various parts of the cables mentioned, but the total length is approaching 4,000 miles. This company manufactured the Saghatien-Tartary cable, 63 miles, for the Great Northern Company; the Aberdour-Granton cable for the Post Office, and for the West Coast of America Company, the Chorillos-Payta cable, 553 miles; the Payta-St. Elena, 222 miles, the Galveston-Brownsville, the St. Elena-Buenaventura; the Buenaventura-Pearl Island; the Salina Cruz-Libertad; the Libertad S-Juan del Sur; the S. Juan del Sur-Pearl Island and the Pearl Island-Panama cables. They also manufactured, for the French Government, the Bona-Bizerta cable, as well as the Sourah-Sfax, Sfax-Gabes cables. It will be seen that altogether this has, as we say, been a busy year, and when we remark that all the land line connections, the instruments, &c., for the West Coast of America cables, were manufactured at Silvertown, it will give some idea of the work. We have from time to time recorded the success in laying these cables, so that we may leave the above list to speak for itself, trusting that the record next year may be as good.

Latimer Clark, Muirhead and Co.—During the past year this well-known firm has been very busy manufacturing electric light apparatus of various kinds, and for the purposes of this work have purchased the Northumberland Works, Millwall, the old works in Regency-street, Westminster, being too small, although they have at various times been greatly enlarged. The heaviest part of the manufacture is now carried on in the new works, the lighter parts only being continued at Westminster. The past year has, we believe, been, on the whole, the busiest that the firm have experienced. Large numbers have been supplied for various parts of the world of Muirhead's patent compound iron telegraph poles, and the increased demand for these poles shows they are appreciated over other patterns. In the more delicate and scientific work which largely occupies this firm, we notice that they have made the duplex apparatus for the Paris New York Telegraph Company's cable, between France and America, and also for one of Mr. Jay Gould's Atlantic cables. Dr. Muirhead has but just completed the installation of the duplex system of working on the latter cable from Cornwall to Nova Scotia, and it works with perfect success. This duplex system is now in daily operation on upwards of 20,000 miles of submarine cable, all of the longest laid, and therefore the most difficult on which to adjust the system. It is needless to explain to most of our readers that duplexing does not mean doubling the cable, but arranging certain apparatus so that the cable can carry in a given time double the number of signals that could be carried under ordinary circumstances. Double is used with a general and not with an exact signification.

Telephones.—In order to complete our review of telephonic work for 1882 we have still to refer to Sheffield and Dundee. The Sheffield Telephone Exchange, which is owned by Messrs. Tasker, Sons, and Co., establishes itself more firmly as an auxiliary to business year by year. That it gives good service is evidenced by the fact that the number of subscribers steadily increases, and that the calls have now reached an average of 1,400 per day. The whole of the "switching" is done by three operators in the central office, on an exceedingly simple plan. Owing to the efficiency of the general maintenance, not more than three faults occur weekly. This efficiency is exceptional, and the management attribute much of it to the use of the Johnson transmitter and Bell receiver, and to the very substantial way in which the lines have been constructed. The extraordinarily severe storms of the past and present winters have not in the slightest degree weakened the stability of the overhead system, not even to the breaking of a single wire. Messrs. Tasker, Sons, and Co. are now devoting much of their attention to electric lighting; they have lately carried out some very successful installations, and others are now in their hands which have not yet been completed. The Dundee and District Telephone Company is another very successful locally established concern. It was started in 1880 under the management of Mr. G. Lowdon. The subscribers now number 277, and as an indication of the use they make of the exchange we may mention that the calls for the week ended Saturday last (January 13) amounted to 12,540.

CORRESPONDENCE.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: What I wished to call Mr. Smillie's attention to, and what he seems not to have noticed is this—that if the carbon varies its resistance under minute changes of pressure as he says, there would be no necessity for the platinum stud, but a piece of carbon to which two binding screws were attached would answer equally well. Let Mr. Smillie examine a Crossley transmitter. It may assist him in altering his opinions. That vibrations take place in the transmitter between the contacts is certain, and if they are too rapid for our ears to distinguish, that is the fault of the ears. The reason carbon alters its resistance more than brass is owing to the difference in form, not of material. If Mr. Smillie were to glaze the surface of a piece of carbon until it were as fine as the brass button entrusted to your charge, Mr. Editor, and afterwards make the surface of the brass button the same exactly as the carbon had been, we should find the greatest variation of resistance to take place in the brass instead of the carbon. Some very fine brass filings, with a little dust thrown in, would show a more variable resistance than the brass button.—Yours, &c., J. Rathbone.

5, Prospect-place, Treorchy, S. Wales.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have been somewhat amused by the very original researches made by Mr. Smillie, and, but for his second letter on the subject, I would not have ventured into the discussion. I think that, having for some years devoted my attention to the subject, I may, perhaps, be able to help clear away the mist with which he is so obviously enshrouded. Taking the latter part of the third paragraph of his second letter—"The resistance of the circuit being diminished, a corresponding diminution of current takes place when the pressure is removed." This appears to my poor apprehension of Ohm's law, and, in accordance with my experience, to point to the conclusion that electricity in Glasgow differs very considerably in its laws and actions to electricity elsewhere, and, therefore, it would probably be unjust to decide that the conclusions of Mr. Smillie are erroneous. Mr. Smillie appears to conclude that because the platinum follows the carbon for a quarter of an inch when the carbon is lifted by hand, it will also follow it with the same facility when the carbon is driven away by impact on the diaphragm. The laws of physics should prove the contrary. Substitute for the diaphragm, platinum, and carbon, three elastic substances suspended each in contact by a string or other means which will allow them each to vibrate freely. Give either of the outer substances a smart blow, and see what happens. If the three bodies are freely suspended there will result a separation between them, the equivalent of the carbon, the diaphragm equivalent being struck, will fly away. If, instead of being freely suspended, the bodies are suspended by springs, the result will only be modified in degree, and in case actual separation does not take place, as it inevitably will do if the blow is hard enough, a diminution of pressure will result between the platinum

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and carbon equivalents. This corresponds to a diminution of current strength, because the resistance is in some inverse proportion to the pressure between the electrodes. I should have deemed it impossible that any one should require a demonstration of the fact that the resistance introduced into a circuit by the contact of carbon and carbon or other conductor varies inversely with the pressure. It is altogether too late to discuss this now, but why carbon should behave in this manner, and why a brass button will not, might prove a more valuable subject. I may say, in conclusion, that carbon is by no means singular in this respect, and that good transmitters are made without it.—Yours, &c., W. E. H.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have carefully read the pros and cons put forth by each party to this discussion, and without taking my stand upon either side, I will just state the experiments I have myself tried, and leave your readers to draw their own conclusions. A few months ago, thinking it possible to bring out a relay transmitter, I obtained a circular box, the lid of which was made to screw on so as to clamp a diaphragm. Through the centre of the diaphragm I inserted a piece of German silver wire pointed (about 16 B.W.G.), and fixed tight to the diaphragm by small adjusting nuts on either side. To the bottom of the inside of the box I fixed a block of carbon with a hole in it containing carbon powder, secured from falling out by a piece of wood on top and a thin piece of ebonite on top of it, again sealed firmly to the top of the carbon with Chatterton's compound. When the diaphragm was placed upon the box and the lid screwed firmly down, the wire pressed well down into the powdered carbon, so that when speaking in the usual way towards the hole in the lid the sound waves impinged against the diaphragm, causing it to vibrate, and thereby moving the wire up and down in the carbon dust, and the words were reproduced at the receiving end, as though they were spoken through a small-toothed comb, in a loose and shaky or grating kind of manner. I tried the experiment with the powdered carbon, pressed well in so as to make it solid, with fine and with coarse powder, but with not much better results. I then enlarged the hole in the block, and fixed a plug of carbon to the diaphragm, so that when the diaphragm was fixed down the plug lightly touched the powder. I got much better results from this, but the loose grating sound was not altogether got rid of, so I tried another diaphragm on top of the first one, but kept apart from it by an india rubber ring. Upon the centre of the top diaphragm I fixed a small stud that just projected very lightly against the lower one when motionless. From this arrangement I obtained better results than I have ever yet heard produced by any other transmitter. The voice was full and loud, the articulation beautifully clear and distinct, and when the speaker shouted into the transmitter the voice came out of the receiver and sounded through the room sufficiently loud to have been heard 10 or 12 yards away. The faintest whisper could be heard quite distinctly.—Yours, &c., GORDIUS.

London, Jan. 15.

STATIC ELECTRICITY IN QUANTITIES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am afraid I cannot work this matter out to satisfy Mr. Von Tunzelmann, p. 207, because it will branch off in so many different lines. I must refer him to my complete work when it appears.

Words generally have several meanings, and it is not easy to convey ideas from one mind to another without some misapprehension from this cause. The distinction between quantity and degree is very clear, yet I do not care to put it into a definition. We have degrees in temperature, we cannot have quantity. So with force as pressure, that is to say static force has no quantity, but has degree; and what I mean is that, when we define a unit quantity of a force, we are not expressing static force itself, but the work it can do upon a quantity of something else. That is the same idea which I state as to electricity itself, viz., that the so-called unit of electricity is simply a measure of work done upon matter by electric force.

The same idea appears to be embodied in the quotation from Newton, which is misinterpreted in that from Professor Clifford, the latter embodying what I consider is the erroneous conception of the unit of electricity. How can force *be* "the change of momentum?" This is really what the unit measures, but the *force* is not the *change*, but the *cause of the change*. Just so the force of gravitation or of steam in a boiler can be measured as degrees of pressure, so many pounds per square inch; but this is not a quantity. To give it a quantitative value, it must be rendered dynamic, and expressed really as the energy due to its unit actions; for unit force and unit energy are the same, because 1 and 1^2 are the same length, and by the law of conservation cause and effect must be equal, and most of our forces (steam pressure, for instance) are merely mathematical expressions for the energy which is expended in their production, which is of course equal to the energy developed by them.

Faraday's ice pail experiment is so thoroughly misunderstood, and its real meaning so utterly obscured by the mathematical theory of electricity, that I cannot pretend to touch upon it here. If Maxwell had lived he would have treated it very differently in due time. His posthumous work shows him gradually passing from the artificial doctrines of electricity, and adopting the same as those I endeavour to sustain; and what is more, most of the leading electricians are unconsciously adopting the same course. All recent books show the temporary confusion of thought due to the change of theory which is occurring.

I told Mr. Von Tunzelmann that I do not hold electricity to *be* energy, and I must now tell him that I do not "consider electricity to be the square root of energy." Electricity is to me nothing but a word; unfortunately, it is a word used to embody two distinct sets of phenomena, and, as I am obliged to use it, I must needs be open to this appearance of confusion when a reader chooses to limit the meaning to one of those it covers, because I cannot explain this every time I write about electricity. All electricians have been involved in this same confusion and difficulty owing to electric quantity and electric energy being both called "electricity," while they hold the relations to each other of numerical order and its square. I do not care to go into the questions of dimensions, and deductions to be drawn from them. But I consider that there is an aspect in which the units of electromotive force, of current, and of resistance are one and the same values, and that aspect is the energy represented in them.

Consider an illustration employed by Dr. Siemens in his B.A. address, and derived from Sir W. Thomson. I quote from Vol. IX., p. 344.:—"Imagine a ball of conducting matter so constituted that it can at pleasure be caused to shrink. Now let it be electrified and left insulated with any quantity of electricity on it. After that let it be connected to the earth by a not perfectly dry silk fibre, and let it shrink just so rapidly as to keep its potential constant. The velocity with which its surface approaches its centre is the electrostatic measure of the conducting power of the fibre. Thus we see how 'conducting power" is in electrostatic theory properly measured by a velocity."

Be it so, but current is necessarily a velocity, and taking the proper unit Q it would be this same velocity. But would not this velocity and unit be also the measure of the "potential?"—Yours, &c., J. T. SPRAGUE.

CABLE TESTING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the articles on submarine cable testing now appearing in your journal, I take the liberty of directing your attention to my paper, "Faults in Submarine Cables," in Vol 3, pp. 372-82, of the *Journal* of the Society of Telegraph Engineers. Mr. Clark, in his remarks thereon

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(*vide* discussion), characterised my plan as better than Lawes's and Lumsden's, and more scientific than any yet proposed, &c.

If the writer of the articles would make use of my paper at the proper time I would be obliged.—Yours, &c.,

J. J. Fahie.

13, Craven-street, W.C., 15th January, 1883.

"GLOW" LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In reference to the discussion going on as regards the nomenclature of lamps, if we are to judge from their appearance, I think the simplest way to settle a discussion will be to apply the term "glow" to such lamps as the Edison, especially those as seen on the Holborn-viaduct, retaining the word "incandescent" for such lamps as the Lane-Fox, Swan, and Maxim, which are worked at a higher temperature, and show a white appearance.—Yours, &c.,

Rue Colbert, Paris, Jan. 15, 1883. Blank.

POSTAL TELEGRAPH SERVICE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: The revision of the commercial staff of the Postal Telegraphs has elicited considerable public interest, and to a lesser extent the pecuniary readjustments lately promulgated in the engineering branch have received outside attention and support; but nothing has yet been done or said with regard to that numerous body of public servants who constitute the working staff of the last-named branch. This might be attributed to a want of influence amongst themselves, or, perhaps, the reason might be found in their being less ready to "air" their grievances through the friendly channel of the Press; hence the fact that no attention has as yet been attracted to their condition.

If you will allow me space I shall endeavour, as briefly as possible, to state a few of the more important grievances peculiar to this section of Government servants.

To commence with, they may be conveniently classified under two heads:—First, Mechanics; second, Linemen.

A comparison between the former and telegraph clerks is somewhat curious. Under the telegraph companies the rate of remuneration for mechanics was similar to that paid at the present time. The maximum rate in the provinces has remained throughout all departmental changes almost unaltered, whilst his fellow worker, the telegraphist, has had his maximum increased two-fold. But the majority of mechanics have other reasons for considering themselves unfairly dealt with by the department. Those who have entered the service since the transfer of the telegraphs are debarred from participating in many of the privileges generously granted to State servants. In cases of sickness his pay is stopped, annual holidays are not allowed except at his own expense, and when incapacitated, possibly after a life's service, he receives no superannuation allowance. The official reasons assigned for this state of affairs are, that mechanics are paid the market price, and that they have at all times a market available for their labour. This dictum practically means that were his services dispensed with in the provinces he must necessarily direct his attention to London. It has been the experience of many provincial mechanics who have left the service with the natural desire to improve their prospects that the telegraph department is the only market for their talents in this country. But the question arises, is the department confined to *employés* destitute of another market? Evidently not, when the best telegraphists are being continually attracted from the service by cable companies and others.

With regard to that portion of the staff which comes under the second head, a similar injustice exists, except in the case of linemen detailed to maintain a sub-district, when they receive the usual Civil Service appointment. But they do not comprise all the linemen constituting a provincial engineer's staff. At important stations, for instance, men are kept continuously employed maintaining batteries at a lower rate of pay than ordinary linemen. This work is none of the healthiest; the battery compartments, as a rule, in large offices, are situated in cellars where light and pure air are not to be expected, and, although battery-men are just as essential to the working of a district as linemen, they are, like mechanics, kept outside the pale of an appointment. It would seem as though the intention were to deprive those who have the most confined and unhealthy occupation of relaxation from duty and help during sickness.

The above are the more glaring anomalies existing within the branch itself, which are certainly sufficient to call for redress. But it will be seen that the whole staff requires attention from the Postmaster-General similar to that bestowed upon other branches of the Post Office telegraphs. Both mechanics and linemen have every reason to feel dissatisfied with the system of promotion pursued at the present time. Vacancies occurring, such as inspectorships, in the engineering branch are, without an exception, filled up from the commercial staff. Again, within the last few years the department has undertaken to manufacture its apparatus, having purchased a factory in London for that purpose. This would necessarily create a number of new appointments; still, we have not a single instance of any of these posts being offered to a provincial mechanic.

Mechanics and linemen when they reach their maximum rate of pay have the remainder of their lives before them destitute of any hope of further promotion. These anomalies in a branch of the civil service which prides itself on its impartial and unfettered system of promotion certainly look like matters requiring parliamentary ventilation. Much has been said with reference to the continued indifference of the department to the acquisition of technical knowledge by telegraph clerks, but what can be hoped for by the amateur technical worker when the professional receives such scant encouragement?—Yours, &c., Provincial.

SELF-REGULATING DYNAMO MACHINES.

[We had intended that with our comment on this correspondence in our issue of January 6 the correspondence should cease, and it is only because there still seems to be some misunderstanding in the matter that we again allude to the subject. In our summary of the work of 1882 we credited Messrs. Crompton and Co. with being the sole makers of the "compound machines." The term self-regulating is preferable to that of compound. The following is taken from a circular issued in New York, dated January 2, 1882:—

Dr. Higgs's System of Regulating Dynamo-electric Machines.

One of the most important and valuable inventions of Dr. Paget Higgs is his method of rendering the regulation of dynamo electric machines automatic.

This system consists in placing proper proportions of the coils of the field of force magnets in both the main and shunt circuits, by which means all auxiliary mechanism is avoided and the machine delivers to the working circuit at all times precisely the amount of current required.

This is the only system by which a dynamo machine, without auxiliary mechanism, is made capable of reducing or increasing the power absorbed according to the amount of current required, the power producing the current being "saved" in proportion as the current is lessened.

This system is now in operation. Its practical working is shown by switching the same current from a 4,000 candle-power lamp to a small incandescent lamp without any change whatever in the current or machine, except that which this system automatically produces and without any injurious effects upon the small lamp, the galvanometer placed in the circuit showing the instantaneous reduction of the current and potential corresponding to the reduction in the work done.

It is plain that no method of regulating that simply turns aside the portion of current not required—as surplus water is run to waste—can be economical like a method that lessens the current itself when the whole is not needed, and thus saves the power required to produce it; and it is equally evident that any mechanical method of controlling a current that does not diminish its production cannot be safe, for in case of any accident to the mechanism, the full current is at hand to do its mischief with

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undiminished power; whereas, the improved arrangement devised by Dr. Higgs—in case of any accident throwing the current out of its legitimate use—instantly reduces it to harmless proportions. This, in view of the accidents liable to occur from powerful electric currents not thus regulated, is a point of great moment.

It is worthy of remark, also, that Dr. Higgs's system is applicable not to one form of dynamo machines only, but to nearly all kinds and varieties made; and while he has designed a particular style of machine—in which, by utilising the electric and magnetic forces in a thoroughly scientific manner, he produces given results with far greater economy than they are otherwise effected—his system of safe and economic control is by no means limited to his own machines, but in a greater or less degree is applicable to all.

This system may be used in regulating currents for the electric transmission of power as well as for the production of electric light, and, in some respects, to even greater advantage, for it makes it practicable to use a greater number of small motors in the same circuit than could be used by any other process, and it secures the machinery perfectly against any danger from "racing" as the work varies or any part of it is stopped.

The great utility of such a system of regulation in the numerous forms in which the electric current is now employed in electric lighting and as a motive power must be apparent to all, and it is with much satisfaction that attention is called to an improvement of so great value at a time when the introduction and use of electricity in the arts is engaging to a large extent the interest of the whole civilised world. Patents on this system have been secured in nearly all the leading commercial countries, and the fact that they have been granted without technical reference is very gratifying evidence of the unquestionable originality of the invention.

Other Inventions. — In the pursuit of his labours as a scientist and electrical engineer, Dr. Higgs has devised various other improvements, some of which are inventions of special value. Among these are his storage battery, proved to be of remarkable utility; his incandescent lamp, burning brightly and steadily without a vacuum, particularly adapted to the lighting of state rooms on shipboard as well as offices and dwellings; his plate lamp for mast-head and street and factory lighting, and burning nearly as many days as ordinary arc lamps burn hours without change of carbons, and his carbon rod lamp, entirely enclosed in a sort of automatically produced vacuum, whereby the carbons are indefinitely preserved, both the last named being without outside conductors or clockwork and automatically regulated at the machine.

These and other important improvements, completed, or in process, are mentioned as indicating the directions in which Dr. Higgs's work as a scientist and inventor is extending, and as desirable accessions to his very remarkable achievement of completely regulating and controlling the dynamo electric machine and current.

The following is from a *private* circular of the Electric Carbon, Storage, &c., Company, of Leith, dated October, 1882:—

The company's machines, as worked under the patents of a well-known electrician, are self-regulating, so that when any of the lamps are put out, the power used is automatically reduced. This is the only system by which a dynamo machine, without auxiliary mechanism, is made capable of reducing or increasing the power used according to the amount of current required. It is plain that no method of regulating that simply turns aside the portion of current not required—as surplus water is run to waste—can be economical like a method that lessens the current itself when the whole is not needed, and thus saves the power required to produce it. Even where the power saved is not important, this self-regulating principle effects great economy in the amount and character of attendance required.

Mr. Jackson, the manager of the company, writes:—"For the last three months we have been selling our compound dynamo machines."

Dr. Higgs thinks that we are doing him a wrong in attributing manufacture to Messrs. Crompton solely, admitting the wrong, if any, to be inadvertently done. Now, Dr. Higgs certainly sees our difficulty, viz., of ignorance. The American circular never had publicity in England, and the Scotch Company's circular is marked private.

Dr. Higgs gives us the fifteenth claim of his English patent:—"I claim the division of the exciting coils of magneto-electric machines by placing the coils of part of the magnets in a shunt circuit, and the remainder in the main circuit, either in the receiving or transmitting machines, &c."

So far as we are concerned, the publication of these extracts enables our readers to judge of the facts of the case for themselves. We have no feeling in the matter except to arrive at the truth. We have, however, one very strong opinion, and it is that, if these "cute" Yankees and Scotchmen object to publicity, they have no one to thank but themselves if they find half a dozen other claimants for a particular design. The world will not stand still to please them, and, speaking for ourselves, we shall always describe the machine and credit the makers of a new machine brought before our notice. There is such a thing as independent investigation and discovery, and A. B. must share the honour with C. D., although A. B. discovers six weeks, months, years, &c., before C. D., yet keeps his discovery secret till after C. D. has made it public to the world. We do not think the publication of Scrutator's letter would be useful. We agree with him as to the expediency of keeping the facts he states well in mind.—Ed. *E.*

THE ELPHINSTONE-VINCENT MACHINE.

As long ago as November 29, 1879 (*The Electrician*, Vol. IV. p. 21), we gave an account of this machine in the form of an abstract of a paper read before the Royal Society. In the same volume, p. 225, will be found a description of further experimental results obtained by Lord Elphinstone and Mr. C. W. Vincent. The machine upon which these gentlemen have been so long at work is now being manufactured by Messrs. Paterson and Cooper for use. We recall the peculiarities of the machine, which will easily be understood from the accompanying figures, showing (Fig. 1) a cross section

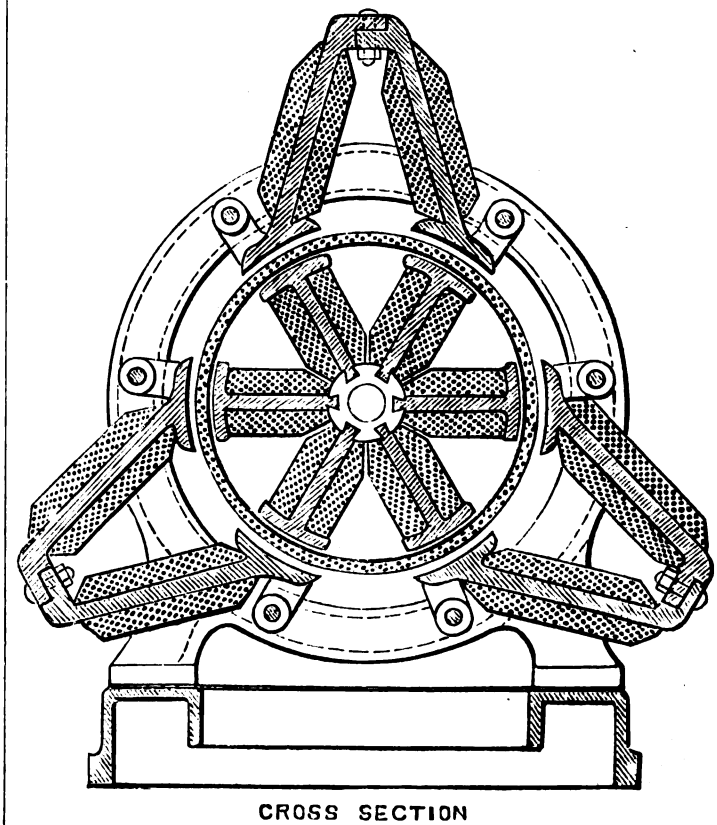

Fig. 1.—The Elphinstone-Vincent Dynamo Machine.

and (Fig. 2) a longitudinal section. A cylindrical drum armature rotates between exterior and interior magnets. The disposition of the twelve poles will be seen from the illustrations. This drum is of papier-maché, upon which the armature coils are laid longitudinally and retained by a wire winding. Each armature coil is made somewhat in the shape of the frame of a saddle. It consists of eighteen sections wound with double wire forming 36 coils. The resistance of the armature between the brushes is ·0374 ohm. There are six brushes. It is claimed that in these machines the openings in the coils cut most perfectly the powerful fields of force produced between the faces of the field magnets, and as

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there is no iron in the armature, the speed with which it may profitably be made to revolve is only limited by its strength. At present the highest speed run is about 1,000 revolutions per minute, but modifications are being introduced which it is hoped will allow the speed to be increased to 1,500 revolutions per minute. At a speed of 855 revolutions per minute, the machine just finished, weighing 26 cwt., generated current sufficient for 288 Swan lamps. The E.M.F. at the brushes varies between 68·85 and 90 volts, depending on speed and external resistance. The resistance of a single outside arm of the field magnets is 1·93 ohm.

The following results of experiments have been handed to us. In these experiments the speed was taken from the countershaft from which the machine was being driven, so that a little allowance must be made for the possible slipping of the belt. The resistance was acidulated water, with lead plates as electrodes. The arrangement was as shown in Fig. 3, where T T represents the terminals of the machine, VM an Ayrton's voltmeter, and G a galvanometer for large currents. As we have said, the armature resistance = ·0374 ohm, while that of the field magnets is 17 ohms, or 4·25 ohms, according as they are used in series or in two parallels —terminals being provided for either method of connection. When the field magnets are joined up so as to have a resistance of 4·25 ohms, the maximum electric efficiency is said to be ·829; while, when the field magnets have a resistance of 17 ohms, the maximum electric efficiency is ·91 :—

Results of Experiments made on December 11, 1882.

	Amperes.	Volts.	Ohms.	Rev.perM.
Field Magnets 4·25ω	160	72	·45	800
,, ,,	160	76·5	·478	850
,, ,,	155	74·25	·479	Not taken
,, ,,	190	68·85	·362	,,
,, ,,	180	72	·4	868
,, ,,	190	74·25	·39	Not taken
,, ,,	200	74·25	·371	900
,, ,,	170	78	·458	880
,, ,,	175	90	·514	880
,, ,,	190	90	·473	900

Experiments on December 12.

	Amperes.	Volts.	Ohms.	Rev.perM.
F. M. 4·25ω	180	76·5	·425	900
,,	190	Used 2 20 c.-p. Swan lamps in series = 288 lamps, taking 1·32ª each		855

Experiments on December 13.

F. M. 4·17ω	100	Ditto ditto = 152 ditto		1,050

The designers of this machine claim for it a number of advantages, such for example as the small amount of waste wire in the coils. Readers who have studied the recent Cantor lectures will know that in the Gramme machine there is a large quantity of useless wire, and that efforts have been made by various makers to minimise this waste. Machines having very different E.M.F.'s can be built upon the same framework. The coils are removable, and a faulty coil can be replaced in a short time. The separate circuits enable the inventor to have an armature with a low resistance, although comparatively thin wire is used. There is no magnetisation or demagnetisation of any part, and the inventors maintain that this is the most efficient system upon which to construct dynamo machines. As has been seen an efficiency of 82·9 to 91·0 per cent. can be obtained according to whether it is desired to attain the best return per h.-p. used, or maximum current without considering h.p. The amount of friction in the machine is small. The amount of current used to excite the field magnets may be varied while working, so that the efficiency of the machine is no question of speculation, but is absolutely de-

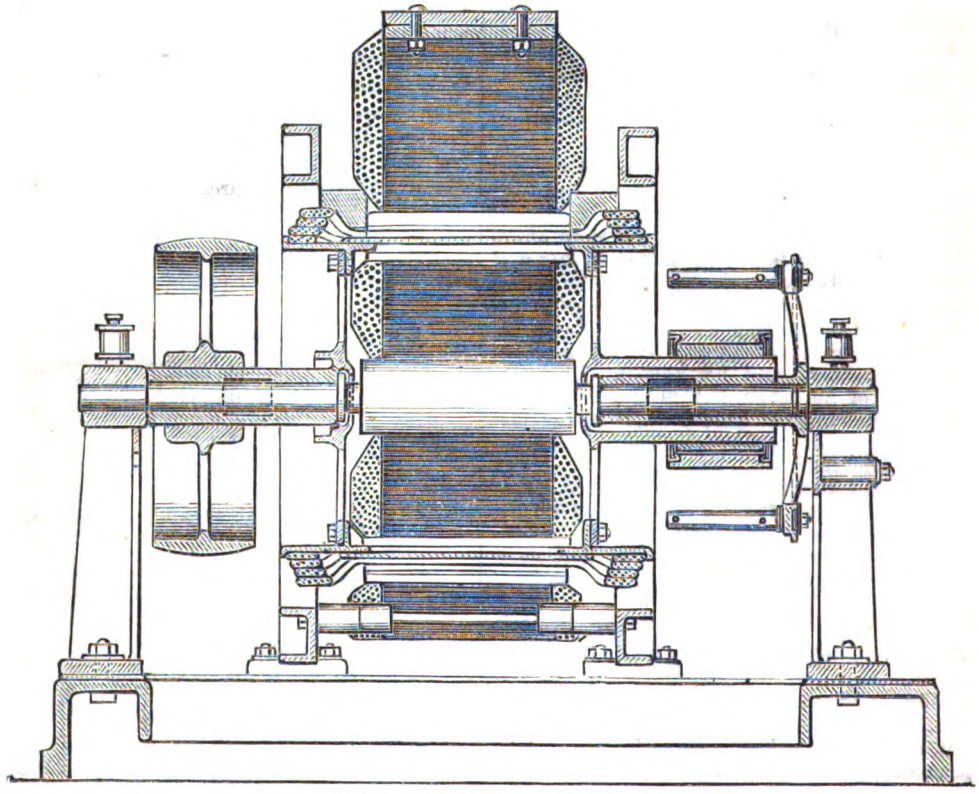

Fig. 2.—The Elphinstone-Vincent Dynamo Machine.

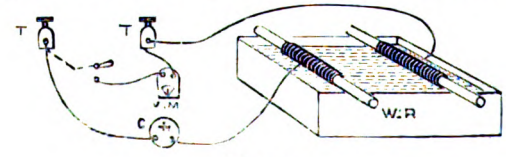

Fig. 3.

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monstrable. The inventors express their opinion very strongly that such a degree of efficiency as 90 per cent. is absolutely unattainable in any machine in which the armature becomes even moderately hot. With 190 to 200 amperes of current the armature is barely perceptibly warmed. A question of mechanical construction has prevented those machines of which the tests are here given being driven at the desired speed of 1,100 or 1,200, which will be attained with some now constructing. The machines can be built of a size to light *a whole town* from a single machine, since its parts are capable of almost indefinite multiplication. We understand that one of these machines is in constant use in one of the recent Swan installations, and that the results of its working are very satisfactory.

Since the above was written we have received the following account of some experiments which were carried out on Monday last at Messrs. Unwin's printing works:—

The experiments were made with a machine running at erratic speed, and show the possibility of keeping a constant electromotive force under those conditions. The engine was driving the whole of the printing machinery at Messrs. Unwin's, as well as the dynamo machine. The time was 9 to 11 a.m. on Monday morning, steam low, and at the close of the experiments water was pumping into the boiler. Weston arc lamps—two in series—were on branches from the main circuit, the current through these was not taken into account; being nominally 30 volt lamps they burnt exceedingly well with 31·5 volts, *i.e.*, 63 volts through the series of two. The lamps were switched in and out at pleasure. The experiments were brought to an end when no current was left in the main circuit with which to steady the E.M.F. The speed of the machine was from barely 500 to 1,000 revolutions per minute. In the latter case the machine was doing no external work. Before any current was taken off the main circuit the readings were:—

MAIN CIRCUIT.

Amperes.	Volts between Terminals.
0	120
135	90
189	72
171	84
157·5	72
162	78
198	66

When the E.M.F. was kept steady and the branches opened the result was:—

MAIN CIRCUIT.

Amperes.	Volts.
135	63
135	61·5
112·5	63
117	63
63	61·5
0	63

Working incandescent lamps with fine filaments under these conditions would be a somewhat hazardous proceeding, but lamps of the coarse sort would work fairly well in parallel with arc lamps. It need hardly be said that no such trying ordeal is in store for the 300 to 400 Swan lamps, with which it is proposed to light Messrs. Unwin's premises. In actual working the speed of the machine will be kept tolerably uniform.

SOCIETY OF ARTS.—The following papers are set down for reading at the meetings of the Society of Arts during the part of the Session after Christmas:—Sir Frederick Bramwell, F.R.S., "Some Points in the Practice of the American Patent Office." Professor George Forbes, "The Electrical Transmission of Power." James J. Dobbie, D.Sc., and John Hutchinson, "On the Application of Electrolysis to Bleaching and Printing."

CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture II.—The Dynamo in Practice.

(CONTINUED FROM PAGE 212.)

It was pointed out, at the conclusion of the former lecture, that none of the four fundamental methods of exciting the field magnetism of a dynamo was perfect in theory, since none could enable a machine either to generate a constant current, or to maintain a constant electromotive force, whatever the resistance of the external circuit for the time being. Now, as the first function of a dynamo in practice is to feed with sufficiency and regularity a system of lamps, and, as those lamps are always† in practice arranged either in series or in parallel, it is clear that in the former case a constant current, and in the latter a constant electromotive force, is required.

Combination Methods.

The discovery of the method of rendering a dynamo machine automatically self-adjusting, so that either its electromotive force (according to circumstances) shall be constant, is due to M. Marcel Deprez, and is a result of the considerations arising from the study of the diagrams of the characteristic curves of dynamos.‡ M. Deprez has, in fact, shown mathematically that if a dynamo be wound with a double set of coils, one of which can be traversed by an independent current, whilst the other set is traversed by the current of the machine itself, there can always be found a certain critical velocity of driving, for which, provided the field-magnets are far removed from their saturation point, the desired condition is fulfilled. Other combination methods have been suggested by Professor Perry and others; and, as the whole matter promises to be of utmost importance in the future practice of constructing dynamos, a summary of the principal methods may be worth tabulating.

(1.) *Series and Separate (for Constant E.M.F.), Deprez.*—This method, illustrated in Fig. 16, can be applied to any

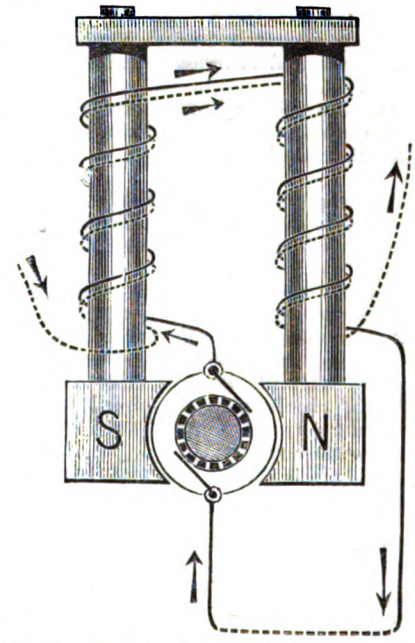

FIG. 16.—Combination of Series and Separate.

ordinary dynamo, provided the coils are such that a separate current from an independent source can be passed through a part of them, so that there shall be an initial magnetic field, independent of the main-circuit current of the dynamo. When the machine is running, the electromotive force producing the current will depend partly on this independent excitement, partly on the current's own excitement of the field-magnets. If the machine be run at such a speed that the quotient of the part of the electromotive force due to the self-excitement, divided by the strength of the current, is numerically equal to the internal resistance or the machinery, then the electromotive force in the circuit will be constant, however the external resistances are

* Reprinted from the *Journal of the Society of Arts*.

† I am aware that occasionally incandescent lamps have been arranged with two or three lamps, in series, in each parallel, or on a multiple series plan. I am not aware of any such arrangement having been satisfactory.

‡ See *La Lumière Electrique*, December 3, 1881.

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varied. M. Deprez has further shown that this velocity can be deduced from experiment, and that, when the critical velocity has once been determined, the machine can be adjusted to work at any desired electromotive force, by varying the strength of the separately-exciting current to the desired degree.

(2.) *Shunt and Separate (for Constant Current), Deprez.*—When cases arise, as for a set of arc lamps in series, it is desired to maintain the current in the circuit at one constant strength, the previous arrangement must be modified, as indicated in Fig. 17,

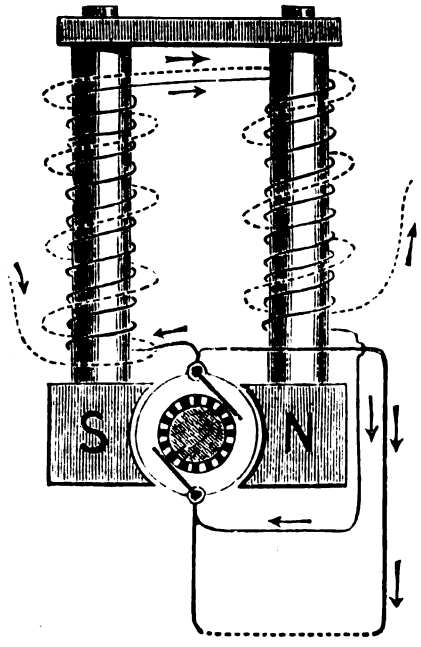

FIG. 17.—Shunt and Separate.

by combining a shunt-winding with coils for a separately-exciting current. This arrangement is, in fact, that of a shunt-dynamo, with an initial magnetic field independent of the strength of the current in the circuit.

Seeing that the only object in providing the coils for separate excitement is to secure an initial and independent magnetic field, it is clear that other means may be employed to bring about a similar result.

(3.) *Series and Magneto (Constant E.M.F.), Perry.*—The initial electromotive force in the circuit, required by Deprez's theory, need not necessarily consist in there being an initial magnetic field of independent origin. It is true that the addition of a permanent magnet, to give an initial partial magnetisation to the pole-pieces of the field magnets, would meet the case to a certain extent; but Professor Perry has adopted the more general solution of introducing into the circuit of a series-dynamo a separate magneto machine, also driven at a uniform speed, such that it produces in the circuit a constant electromotive force equal to that which it is desired should exist between the leading and return mains.*

* Professor Perry gives, in his specification, the following numerical illustration, to which the only exception that can be taken is, that with so high a resistance as that of three ohms in the machine the system must be very uneconomical. "As an example, if there is only one dynamo machine, and if the resistance of the main cable, return cable and machines, in fact, of that part of the total circuit which is supposed to be constant, be, let us suppose, three ohms, then we find that the dynamo machine ought to be run at such a speed that the electromotive force, in volts, produced in its moving parts is three times the current in amperes, which flows through the field-magnets, consequently this speed can readily be found by experiment. Suppose the constant electromotive force of the magneto machine to be 50 volts; its resistance 0·3 ohm, and the resistance of the dynamo machine and of the other unchanging parts of the circuit 2·7 ohms; and suppose that the speed is that at which the electromotive force produced by the rotating armature of the dynamo is three times the current. Now, let there be a consumer's resistance of 2 ohms, the total resistance is 5 ohms. Evidently the electromotive force produced in the dynamo is 75 volts (for call this electromotive force x, then the current will be $x \div 3$, whence it follows that $\frac{x + 50}{5} = \frac{x}{3}$, or $3x + 150 = 5x$, or $x = 75$), and the total electromotive force in the circuit is therefore 125 volts, and, as the total resistance is 5 ohms, the current is 25 amperes, giving an electromotive force of 50 volts between the ends of the consumers' part of the circuit. Now, if the consumers' resistance increases to, say, 12 ohms, by some of the consumers ceasing to use their circuits, there is an instantaneous alteration of the electromotive force produced in the dynamo to 12½ volts, or 62½ volts in the whole circuit, and 62½ divided by 15 gives 4 1-6 amperes; and this means 4 1-6 multiplied by 12 or 50 volts as before, between the ends of the consumers' part of the circuit. (Here, again, the calculation is:— $\frac{x + 50}{15} = \frac{x}{3}$, whence $x + 150 = x$, or $12\frac{1}{2} = x$.)—(S.P.T.)

This arrangement, which is depicted in Fig. 18, may be varied by using a shunt-wound dynamo, the magnets being, as before, included in the part of the circuit outside the machines. The combination of a permanent magnet with electro-magnets in one and the same machine is much older than the suggestions of either Deprez or Perry, having been described by Hjörth in 1854.

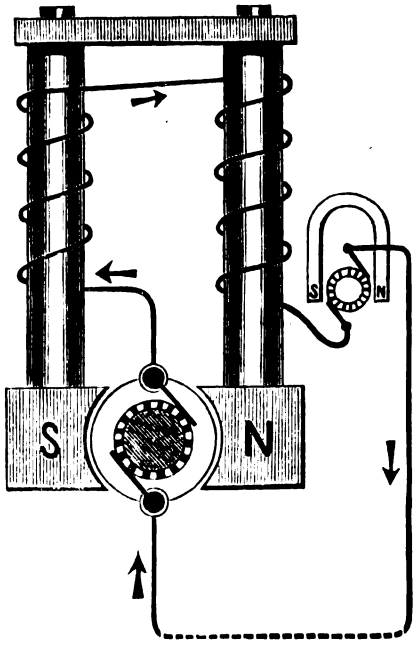

FIG. 18.—Series and Magneto.

(4.) *Shunt and Magneto (Constant Current), Perry.*—Perry's arrangement for constant current is given in diagram in Fig. 19, and consists in combining a shunt-dynamo with a magneto machine of independent electromotive force, this magneto-machine being inserted either in the armature part or in the magneto-shunt coils of the machine. As before, a certain critical speed must be found from experiment and calculation.

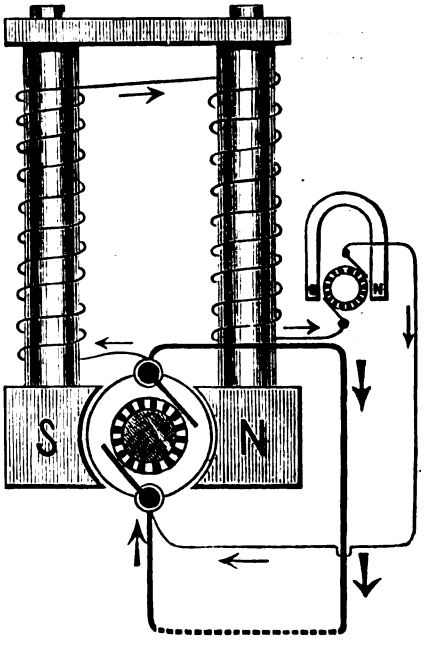

FIG. 19.—Shunt and Magneto.

(5.) *Series and Shunt.*—A dynamo having its coils wound, as in Fig. 20, so that the field-magnets are excited partly by the main current, partly by a current shunted across the brushes of the machine, is no novelty, having been used in Brush dynamos* for some years past. The arrangement is not so per-

* The shunt part of the circuit, originally called the "teazer," was adopted at first in machines for electro-plating, with the view of preventing a reversal of the current by an inversion of the magnetisation of the field-magnets, but has been retained in some other patterns of machine on account of its usefulness in "steadying" the current. I am informed that Messrs. Siemens and Halske have also used this combination for some time past.

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fect as either of the preceding, being more limited in operation. If the shunt coils be comparatively few, and of high resistance, so that their magnetising power is small, the machine will give approximately a uniform electromotive force; whereas, if the shunt be relatively a powerful magnetiser, as compared with the

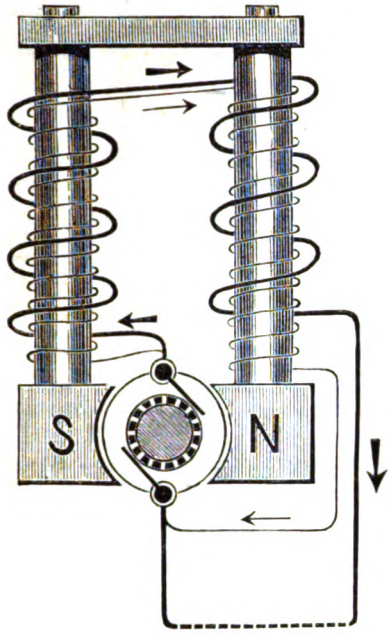

FIG. 20.—Series and Shunt.

few coils of the main circuit, the machine will be better adapted for giving a constant current; but, as before, each case will correspond to a certain critical speed depending on the arrangement of the machine.

(6.) *Series and Long Shunt.*—I propose to give this name to a combination closely resembling the preceding, which has not yet, so far as I am aware, been actually tried. If, as in Fig. 21, the

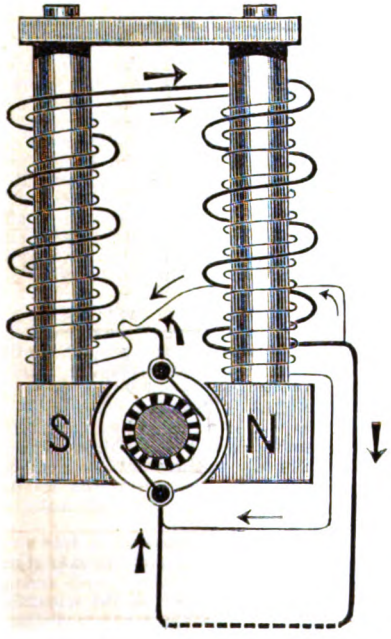

FIG. 21.—Series and Long-Shunt.

magnets are excited partly in series, but also partly by coils of finer wire, connected as a shunt *across the whole external circuit*, then the combination should be more applicable than the preceding to the case of a constant electromotive force, since any variation in the resistance of the external circuit will produce a greater effect in the "long shunt" than would be produced if the resistance of the field-magnets were included in the part of the main circuit external to the shunt.

Although the last two combinations are not such perfect solutions of the problem as those which precede, they are more likely, in my opinion, to find an immediate application,* since they can be put into practice upon any ordinary machine, and do not require, as in the first four combinations, the use of separate exciters, or of independent magneto-machines.

All these arrangements presuppose a constant velocity of driving; but they are not the only ones consistent with this condition. An ordinary series dynamo may be made to yield a constant current, by introducing across the field-magnets a shunt of variable resistance, the resistance of the shunt being adjusted automatically by an electro-magnet, whose coils form part of the circuit. This is actually done in the automatic regulator attached to Brush dynamos, as used in supplying a series of arc lights. A shunt-dynamo may similarly be controlled, so as to yield a uniform electromotive force, by introducing a variable resistance into the shunt-magnet circuit, as is done in some of Edison's dynamos. To make the arrangement perfect, this variable resistance should be automatically adjusted by an electro-magnet whose coils are an independent shunt across the mains of the external circuit.

Yet another way of accomplishing the regulation of dynamos is possible in practice, and this without the condition of a constant speed of driving. Let the ordinary centrifugal governor of the steam-engine be abandoned, and let the supply of steam be regulated, not by the condition of the velocity of driving, but by means of an electric governor, such as an electro-magnet working against an opposing spring. If this electro-magnetic governor is to maintain a constant electromotive force, its coils must be a shunt to the mains of the circuit. If it is to maintain a constant current, its coils must be part of the main circuit. Such a governor ought to be more reliable and rapid than any centrifugal governor intended to secure a uniform speed of driving.

Organs of Dynamos.

I now propose to return to some of the rules and suggestions which we arrived at a week ago, in considering the dynamo in theory, and see how they are borne out in the dynamo as constructed in practice. I shall try to illustrate the various points that come under review, as far as possible, from the more recent types of dynamo.

Field-Magnets.

In the classification of dynamos, laid down in my first lecture, we found that those of the first class required a single approximately uniform field of force, whilst those of the second class required a complex field of force differing in intensity and sign at different parts. Accordingly, we find a corresponding general demarcation between the field magnets in the two classes of machine. In the first, we have usually two pole pieces on opposite sides of a rotating armature. In the second, a couple of series of poles set alternately round a circumference or crown, the coils which rotate being set upon a frame between two such crowns of poles.

Confining ourselves, at first, to the first class of machines, we find that, in practice, their magnets differ widely in construction and design. In very few of the existing patterns is there much trouble taken to secure steady magnets, by making them long, heavy, and solid, or with very heavy pole pieces. I have repeatedly, in testing dynamos, had to report that an unnecessary amount of wire had been wound upon the field magnets; and I find that the usual reply is that, with less wire, the machine does not work so well. If, however, it is found necessary to wind on so many coils upon the magnets as to bring these practically to saturation long before the machine is doing its maximum work, it is clear that either the iron is insufficient in quantity, or it is deficient in quality. In the Bürgin machines, where cast-iron field magnets are employed, the smaller magnetic susceptibility of this metal is made up for by employing a great weight of it. In Siemens's smaller dynamos, the amount of iron employed in the field magnets would be quite insufficient if it were not of high quality. As it is, I am of opinion, the mass of it (especially in the polar parts) might, with advantage, be increased. In some of the early machines of Wilde, and in Edison's well-known dynamos, long field magnets, with heavy pole pieces, are found. Edison's dynamos, indeed, are all remarkable in this feature; the pole pieces and the yoke connecting the iron cores of the coils are made abnormally heavy. This is not more noticeable in the giant dynamos, used at the Holborn-viaduct, than in the smaller machines used in isolated installations for sixty and for fifteen lights.

The principle of shaping the magnets, so that their external form approximates to that of the magnetic curves of the lines

* Since the above was written, an account of a similar combination to the 5th, mentioned above, has appeared in the pages of *The Electrician*, under the name of "Crompton's Compound Dynamo." Mr. R. M. Bosanquet, of St. John's College, Oxford, has also suggested a similar arrangement for charging accumulators with a constant electromotive force.

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of force, is, to some extent, carried out in such widely differing types of machine as the Gramme with "Jamin" magnet, the Jürgensen dynamo, and Thomson's "mousemill" dynamo. The two machines last named exhibit several curious contrasts. In the Jürgensen, the field-magnets have heavy poles pieces; in the Thomson there are none; and in the Thomson machine the iron core is thicker at the middle than at the ends. In both there are auxiliary internal electro-magnets, fixed within the rotating armature, to concentrate and augment the intensity of the field, according to the device patented by Lord Elphinstone and Mr. Vincent. In the Thomson machine the coils are heaped on more thickly at the middle of the field-magnets; in the Jürgensen, the coils are crowded up around the poles. The latter arrangement I condemned from the point of view of theory last week. If we may judge from a report on this machine by Professors Ayrton and Perry,* the arrangement is not satisfactory in practice, as there are more coils than suffice to magnetise the magnets. Is it possible that the mistake is not in having too many coils, but in having them in the wrong place?

Another suggestion, which was indicated from theoretical considerations, was that of laminating the pole-pieces, so as to prevent the production in them of wasteful Foucault currents. Here I find that but one machine has been designed in which this precaution is carried into effect. This is the disc-dynamo of Drs. Hopkinson and Muirhead, the field magnets of which are made up of laminæ of iron, cast into a solid iron backing.

Another matter in which, up to the present time at least, there is nothing but empirical practice to guide us, is the form to be given to pole pieces, in order to produce the best effect. In fact, we have such singular divergence in practice, as to suggest the thought that little importance has been attached to the matter. Yet upon the form and extent given to the pole pieces, depend considerations of no less importance than the reduction of idle wire in the armature, the reduction of sparking at the commutator, and the avoidance of counter-electromotive forces in the armature. If the pole pieces are badly shaped for their work, or approach one another too far round the armature, they may completely perturb the approximate uniformity of the field, and may cause the central portion of the field to be of much weaker intensity than the two lateral regions between the edges of the pole pieces. When this is the case, the rotating coils are virtually moving in a double field, and it is even possible that, in consequence, the direction of the currents induced in the individual coils may be reversed four or six times as they make one rotation. In such a case the distribution of potential round the separate bars of the commutator will be abnormal, as we shall see later on.

(TO BE CONTINUED.)

* See *Telegraph Journal and Electrical Review*, Sept. 23, 1882

INTERNATIONAL ELECTRIC EXHIBITION, VIENNA, 1883.

GENERAL REGULATIONS.

We have received a copy of the regulations relating to this exhibition, which are as follow:—

ARTICLE 1.—By a decree of the Imperial Ministry of Commerce of the 8th of June, 1882, No. 17,202, permission was given to hold an International Electric Exhibition in Vienna, and the Rotunda, together with the remaining buildings erected for the Universal Exhibition of 1873 devoted for this purpose.

ARTICLE 2.—This Exhibition shall be opened on the 1st of August and shall be closed on the 31st of October, 1883.

ARTICLE 3.—To organise and carry through the International Electric Exhibition, a General Commission has been formed which has secured the necessary means by a guaranteed fund. This General Commission has formed from among its members several committees, a central committee, a finance committee, a technical committee, a committee of arrangements, and shall form further committees as needed. A managing committee has been appointed to carry out the resolutions passed by the General Commission and by the several committees, and to manage all matters relative to the Exhibition. All communications with the representatives of foreign countries and with the exhibitors or their representatives shall be carried on through the Managing Committee.

ARTICLE 4.—The exhibits to be admitted are divided, according to the principle which they embody, into the following classes:—Class I. Magneto-electric and dynamo-electric machines. Class II. Galvanic cells, batteries, accumulators, thermo-electric piles. Class III. Scientific apparatus, instruments for electrical measurements, electrostatic apparatus. Class IV. Telegraphs. Class V. Telephones, microphones, photophones. Class VI. Electric lighting. Class VII. Transmission of power. Class VIII. Cables, wires, conductors. Class IX. Application of electricity to chemistry and metallurgy. Class X. Application of electricity to war. Class XI. Railroad electrical appliances. Class XII. Application of electricity to mining, navigation, and agriculture. Class XIII. Electro-medical apparatus. Class XIV. Application of electricity to automatic registration, to horology, meteorology, astronomy, and geodesy. Class XV. Miscellaneous. Class XVI. Application of electricity to domestic use, to art-industry and decoration. Class XVII. Application of machinery to electrical industry. Boilers, steam, gas and hydraulic engines. Class XVIII. Historical collections. Methods of instruction. Bibliography.

ARTICLE 5.—Applications for space so far as possible should be made out according to the annexed forms and must be in the hands of the managing committee of the International Electrical Exhibition, Wallfischgasse 9, Vienna, at the latest by the 1st March, 1383. Printed forms are to be obtained at home from the managing committee, the Boards of Trade and Commerce, from the scientific and commercial societies, and abroad from the Austrian-Hungarian Consuls. When necessary special local committees shall be formed to co-operate with the managing committee.

ARTICLE 6.—The acceptance of exhibits rests with the General Commission, applicants shall be informed of the decision of the commission within two weeks after receipt of application.

ARTICLE 7.—Exhibitors shall be informed of the final allotments of space by the 1st May of 1883.

ARTICLE 8.—Exhibitors shall pay no rent for the space allotted to them. The General Commission undertakes, at its own expense, the arrangement and general decoration of the building. Exhibitors must bear the expense of the installation and decoration of their own exhibits. The plans of these must be submitted to and approved of by the Managing Committee.

ARTICLE 9.—Motive power shall be supplied to exhibitors who require it at 20 kreuzers per h.-p. per hour (5d. or 10 cents). The motive power required for the purposes of the scientific commission shall be supplied free.

ARTICLE 10.—The Exhibition shall be open to the public twice daily, during the day and in the evening. The hours of admission shall be fixed and published in due course.

ARTICLE 11.—Exhibitors shall be entitled to free passes for themselves, their representatives, and for the requisite number of assistants and workmen.

ARTICLE 12.—The general commission shall provide that rigorous watch be kept over the exhibits and that proper order be maintained. The commission, however, does not hold itself responsible for any loss incurred through injury to exhibits through theft or fire. The exhibitors are at liberty to insure their exhibits at their own expense.

ARTICLE 13.—Exhibitors must provide that in the installation and working of their exhibits every danger to the public and to the buildings be avoided, and must conform themselves in this respect to special arrangements of the General Commission.

ARTICLE 14.—The exhibits must be accessible to the free inspection of the public every day during the regular hours of admission during the entire time of the exhibition. No exhibit shall be withdrawn before the close of the exhibition without the special permission of the General Commission.

ARTICLE 15.—Exhibitors must bear the expense of maintaining in order their own exhibits.

ARTICLE 16.—Exhibits must be in the name of the manufacturer, and with his consent they may also bear the name of the firm which is authorised to sell them. Every exhibit must be clearly marked with the name of the firm exhibiting.

ARTICLE 17.—All copies of exhibits, whether drawings, photographs, or otherwise, are only allowed with the consent of the exhibitors and of the General Commission.

ARTICLE 18.—The sale and removal of exhibits may occur with the consent of the General Commission; every object, however, withdrawn must be at once replaced by a duplicate.

ARTICLE 19.—The receipt of goods at the Rotunda shall begin on the 1st June, 1883, and by the 5th July, 1883, all exhibits must be entirely unpacked and set up. The General Commission reserves the right to dispose of the space not occupied by the specified date. The General Commission shall have the right to complete such installations as are not finished in time at the expense of the exhibitor, or to exclude him entirely.

ARTICLE 20.—One month after the close of the exhibition the exhibitors must have completely removed their exhibits. After the lapse of this time all exhibits not removed from the exhibition grounds shall be removed and deposited in some suitable place at the expense and risk of the exhibitor. In case of such goods not being removed within six months after the close of the Exhibition, they shall be sold and the proceeds made use of in accordance with Article 27.

ARTICLE 21.—The General Commission has taken the necessary steps to enable exhibitors to enjoy the advantage of the patent laws from the time of the entry of their goods to the exhibition grounds until exit therefrom, and to enable foreign exhibitors to enjoy exemption from duty in case of the re-export of their goods before the end of the year 1883. The special conditions relative hereto shall be given in due course.

ARTICLE 22.—No prizes will be awarded by a jury. During the exhibition, a technical and scientific commission shall be organised in co-operation with the exhibitors, in order to carry out electrical measurements and other scientific investigations with a view to testify results.

ARTICLE 23.—The General Commission shall make arrangements for scientific and technical lectures.

ARTICLE 24.—A complete catalogue shall be drawn up by the General Commission and published at the opening of the exhibition.

ARTICLE 25.—Further special regulations and arrangements relative to service, to the use of motive power, to the scientific experiments, to transportation of goods, to advertisements and to similar matters shall be duly sent to exhibitors, who shall also be kept informed of all important measures and occurrences.

ARTICLE 26.—The ultimate decision where cases of dispute or complaint may arise shall be reserved to the General Commission.

ARTICLE 27.—The net proceeds of the exhibition shall be devoted with the agreement of the Imperial Ministry of Commerce either to such scientific institutions as may carry out further the aims of the exhibition, or to the pursuit of important inventions in the field of electrical science.

Vienna, the 6th December, 1882.

For the General Commission of the Exhibition:

Honorary President: Graf Hans Wilczek. President: Victor Freiherr von Erlanger.

Managing Committee: Carl Pfaff. Rudolf Ritter von Grimburg.

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EASTERN TELEGRAPH COMPANY.

Report and accounts of the directors for the half year ended 30th September, 1882, to be presented to the twenty-first half-yearly ordinary general meeting, to be held at the City Terminus Hotel, Cannon-street, in the City of London, on the 25th of January, 1883, at one o'clock:—The directors submit the accounts and balance-sheet for the six months ended 30th September, 1882. The revenue for the period amounted to £341,151 13s. 1d., from which are deducted £69,809 11s. 1d. for the ordinary expenses, and £52,801 5s. 6d. for expenditure relating to repairs and the laying of new cables, &c., during the half year. After providing £5,496 6s. 3d. for income-tax, there remains a balance of £213,044 10s. 3d., to which is added £1,033 18s. 7d. brought from the preceding half year, making a total available balance of £214,078 8s. 10d. From this balance £22,682 19s. 2d. has been paid for interest on debentures, and £20,559 2s. 2d. for dividend to 30th September, 1882, on the preference shares, leaving a balance of £170,836 7s. 6d. The directors have paid two interim dividends on the ordinary shares for the quarters ending 30th June and 30th September, 1882, and a bonus of 1s. per share for the half year, amounting together to £114,000. The balance, £56,836 7s. 6d., is carried forward to the next account. The revenue includes £15,600 dividend for the half year upon the Company's shares in the Eastern and South African Telegraph Company, being at the rate of 8 per cent. per annum, and also £3,551 16s. dividend for the like period on the shares of the Black Sea Telegraph Company belonging to this Company. The various sections of the Company's cables are in working order. All the Company's land lines between Alexandria and Suez were cut at the commencement of hostilities in Egypt, and were not restored until the fall of Tel-el-Kebir. The total interruption of telegraphic communication through Egypt was of course productive of great inconvenience to the public and loss to the Company, but the latter was to some extent compensated by the extra business arising from the naval and military operations of Her Majesty's Government in that country. In order to facilitate these operations and to obtain a resumption of through traffic as early as possible, an arrangement was made by the directors with Her Majesty's Government and His Highness the Khedive, under which a cable was laid by the Company's s.s. John Pender between Alexandria and Port Said, and a temporary land line was erected between Port Said and Suez by way of the Canal. An agreement was subsequently entered into with the Suez Canal Company for the erection and working of a permanent aerial line connecting the cables at Port Said and Suez, and to be used by the Company as an alternative route through Egypt to Aden, India and beyond. This work is now being carried out. In continuation of the new route, and with the view of expediting the important traffic with the Cape of Good Hope and Natal, the directors have made a contract with the Telegraph Construction and Maintenance Company for the manufacture and laying of a third cable between Suez and Aden, which cannot fail to be of great advantage in the working of the increasing business over that section. The cost of this cable, and of that between Alexandria and Port Said, will amount to about £320,000, the greater part of which it is proposed to take from the reserve fund. The above operations, although involving a large expenditure, were, in the opinion of the directors, absolutely necessary alike in the interests of the Company and of the public. Her Majesty's Government have recognised the important services rendered by the Company in official correspondence which will favourably affect the future position of the Company. During the half year the Company's ships have been fully occupied. The s.s. Chiltern served as a floating station at Alexandria for three months, after which the s.s. John Pender performed that duty, the Chiltern being employed in the repairs of the Red Sea and Bombay cables. The s.s. Caroline was chartered for conveyance of cable and stores, and the Telegraph Construction and Maintenance Company's s.s. Seine was employed in the repairs of the Direct Lisbon cable, which she successfully accomplished on the 12th August in 2,700 fathoms of water, the Company's s.s. Retriever rendering assistance in the work. The directors have purchased and equipped a new repairing steamer, the Volta, of a similar class to the Retriever, experience having shown that repairing operations can frequently be carried out successfully and economically by vessels of this tonnage. The new vessel will be paid for out of the maintenance ships fund. The new cable (referred to in the last report) from Malta to Tripoli was opened for traffic on the 27th October, 1882. An agreement has been made with the Direct Spanish Telegraph Company which it is expected will be for the benefit of both companies, and tend to improve the working of the traffic. In accordance with the provisions of the Articles of Association, two of the directors—Lord Sackville A. Cecil and General Lord Alfred Paget—retire by rotation, and, being eligible, offer themselves for re-election. The auditors, Mr. Henry Dever and Messrs. Quilter, Ball, and Co., retire and offer themselves for re-election. A form of proxy is enclosed, which, to be available, should be signed and returned to the secretary on or before the 22nd inst.

THE ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.

The report of this Company states that the capital has been increased to £245,000 by the issue of 700 fully paid up shares as compromise to American vendors in regard to mutual claims in connection with the Belgian and Russian patents. The value of all the patents of the Company is now stated at £179,466. The purchase of the Russian, Italian, and Scandinavian patents is not yet completed, and the Company have an interest of one-third in the future profits on account of the French patents. The balances of the year show a cash profit for concessions of £407,295, and on manufacturing account of £33,713, making a total of £443,943. Out of these balances an interim dividend of 100 per cent was paid, leaving £198,937, to which is to be added a further sum of £50,000 to be paid in March by Mr. Lane-Fox. The directors propose to deal with this sum by writing off from the purchase price of the patents £132,950, which will be represented in future by shares in the sub-companies; and write off also 10 per cent. on account of depreciation. The non-payment of dividend for the half year just closed is explained by the fact that the Company have stocks on hand, the cost price of which is £93,000, but the sale of which at large profits has been interrupted by the action of the Electric Lighting Act. The directors express, in conclusion, their regret that the extraordinary prosperity which attended their efforts during the early part of the past year has been followed by a temporary reaction towards its close, resulting from circumstances beyond their control. They cannot, however, but believe that when the numerous provisional orders now applied for, both by municipal authorities and by the licensees of the Corporation, have been obtained, a fresh impetus will be given to electric lighting generally. The secretary writes further that, at a recent Board meeting, it was found "that the total amount in cash and shares standing to the credit of the Corporation on the 31st of December last was £248,937 15s. 2d. From this amount they (the Board) propose, subject to the confirmation of the shareholders, to write off £132,950 in shares from the purchase price of patents, and £6,649 2s. 2d. for 10 per cent. depreciation of plant, buildings, &c., leaving £109,338 13s. to be carried forward to the credit of profit and loss account for 1883. The directors consider, having regard to the large stocks on hand, and the present temporary depression of electric lighting business, that they will be adopting the more prudent course in abstaining from declaring any dividend for 1882 further than the 100 per cent. already paid in that year."

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Jan. 17.		Business Done Week Ending Jan. 17. Highest.	Lowest.
Anglo-American	50,	51	50¾	50¼
Do. Preferred	82,	83	82¾	81¼
Do. Deferred	18½,	19½	19⅜	19
Brazil Submarine	11¾,	12⅛	12⅛	11 15-16
Cuba	10,	10¼	10¼	10¼
Do. Preference	17,	18	17½	17½
Direct Spanish	6¾,	7	7	7
Do. Preference	16,	17	16	16
Direct United States Cable	12⅛,	12⅜	12¼	12
Eastern Telegraph	10⅞,	11⅛	11⅛	10 15-16
Do. 6 per Cent. Preference	13,	13½	13 9-16	13⅜
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11⅞,	12⅛	12⅛	11⅞
German Union	10¾,	10⅞	10⅞	10⅝
Globe Telegraph and Trust Company.	6¾,	6⅝	6 9-16	6 7-16
Do. Preference	12⅝,	12¾	12¾	12⅝
Great Northern	12,	12½	12½	12 1-16
Indo-European	32,	33	32½	32½
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	8	—	—
Reuter's	12,	12½	—	—
Submarine	252,	257	254	254
West India and Panama	1½,	1⅝	—	—
Do. 1st Preference	7,	7½	7	7
Western Brazilian	7⅛,	7¼	7 13-16	7⅛
West. Union 7 per Cent. 1st Mortgage	122,	126	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¼	⅜	⅛
Oriental	⅛,	¼	⅜	11-16
United Telephone	10¾,	11¼	11¼	10¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	6,	6½	7⅛	6½
Do. (fully paid)	10,	12	13⅛	12
Hammond Light	2½,	3	3	2⅞
Eastern Electric (£4 paid)	1⅛,	1⅜	—	—
Pilsen, Joel, and General Electric	1,	1⅛	⅜	⅜
Swan	2⅛,	2⅜	2⅜	2 5-16
Maxim-Weston	—,	—	⅜	⅜

TRAFFIC RECEIPTS FOR DECEMBER, 1882.

Companies.	Dec., 1882.	Dec., 1881.	Increase.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,741		—
Direct Spanish Telegraph Company	1,346	1,458	—	112
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	49,610	49,844	—	234
Great Northern Telegraph Company	17,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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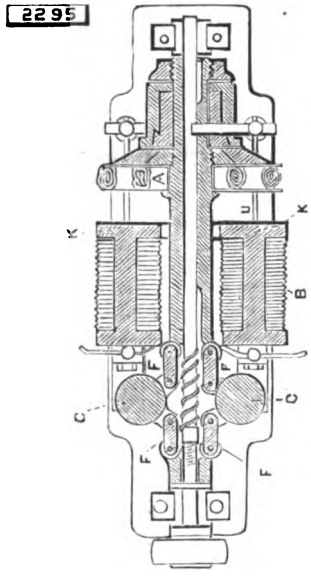
RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

2295. IMPROVEMENTS IN COMPENSATING DYNAMO-ELECTRIC MACHINES, *B. H. Chameroy, Maisons Lafitte, France.*—16*th May*, 1882. 6*d*.

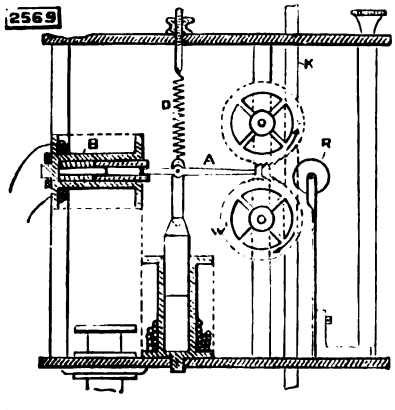
The inventor claims a dynamo-electric machine in which the strength of the current is controlled by causing the variations of said current to regulate the distance between the exciting coils and the electro-magnets, either directly by the influence of the current in the machine, or by the intervention of mechanical devices. The figure



gives a sectional plan of one method. The electro-magnets are movable, and supported on axles C C; they are capable of moving away from armature A. If any lamps connected with the dynamo are extinguished so as to increase its resistance, the lower part of electro-magnets K K will, by reason of their magnetisation, move towards the metallic masses F F1, and the separation of K K from A diminishes the current in A.

2569. IMPROVEMENTS IN ELECTRIC LAMPS, *T. E. Gatehouse, Camberwell, and H. R. Kempe, Barnet.*—31*st May*, 1882. 6*d*.

The accompanying figure shows the inventor's lamp. The solenoid B is connected through any make or break arrangement, so that it is intermittently excited, attracting its core in opposition



to the spring shown in the figure, and thus giving a reciprocating to-and-fro motion to arm A. Lower solenoid is of high resistance, and is placed in a shunt from the main circuit. Its core is drawn upward by an adjustable spring, D. When the carbons are too near this solenoid is weak, and spring D raises arm A, so that a tooth at its end engages as a pawl with the upper wheel. By the reciprocation of arm A this wheel is caused to turn upwards the same way as the arrow, thus raising the carbon and enlarging the arc. The reverse takes place when the arc is too long and the solenoid strong. Wheel R simply presses carbon K against wheels W and W1. The invention also relates to a novel method of including an incandescent lamp in a shunt circuit as part of the resistance thereof.

2532. AN IMPROVED METHOD OF TREATING CERTAIN MATERIALS TO RENDER THEM DIELECTRICAL, *E. W. Beckingsale, Bedford Park, Middlesex.*—27*th May*, 1882.—(*Not proceeded with.*) 2*d*.

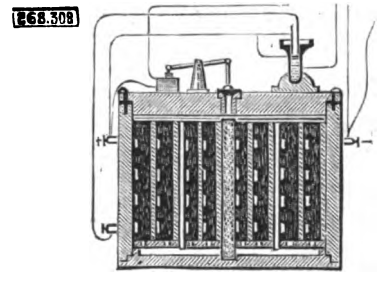
This relates to the injection of hydrocarbons into bricks, stones, and other porous materials, so as to render them non-conducting.

2628. IMPROVEMENTS IN APPARATUS FOR COLLECTING AND TRANSMITTING ELECTRIC FLUID, *&c., H. Defty, Middlesbrough.*—5*th June*, 1882.—(*Not proceeded with.*) 2*d*.

This invention relates to apparatus for collecting electricity from the natural chemical combinations of metals and ores, and transmitting the same for illuminating and other purposes.

268,308. SECONDARY BATTERY, *Eli T. Starr and E. Eugene Starr, Philadelphia, Pa.*—*Filed October 6th*, 1882.

Claim.—(1) The combination, substantially as hereinbefore set forth, of a closed battery vessel containing electrodes or elements, a valve closing an opening in said vessel, an electro-magnet to control said valve, and an electric circuit, substantially as described, including said electrodes and said magnet, whereby during the time the battery is giving off gas the said valve will be automatically opened to permit of its escape and at other times will be closed. (2) The combination, substantially as hereinbefore set forth, of an air-tight secondary battery vessel, electrodes contained in said vessel, a valve closing an opening in the said vessel, an electro-magnet mounted on said vessel to control said valve, and a line in which said electro-magnet is situated, by which the charging current is conducted to said battery, whereby while the charging current is passing to the battery the valve will be raised to permit the escape of surplus gases generated in the battery by said current, and when the charging current is cut off said valve will be closed. (3) An element or electrode for secondary batteries, consisting of a support or plate with a layer of porous active material applied thereto, composed of oxide of lead or its equivalent, mixed with fibre or



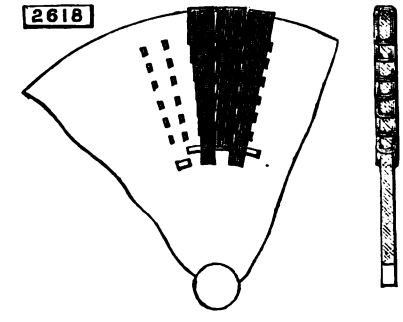
filaments—in contradistinction to pulverised coke or sawdust—whereby the porous mass is bound together and held more securely to its support or plate. (4) The improved porous active composition for secondary batteries, consisting of a mixture of lead or its quivalent with fibre or filaments, substantially as described. (5) The combination, substantially as hereinbefore set forth, in a secondary battery, of the battery vessel, the positive and negative electrodes thereof, each electrode consisting of a series of plates coated with porous material to be acted upon by the charging current, and each electrode being provided with a space extending through it for the free escape of the surplus gases, and the porous partition separating said electrodes. (6) The combination, substantially as hereinbefore set forth, in a secondary battery, of the closed battery vessel having a valve opening at its top for the escape of its surplus gases generated in charging the battery, the perforated partition forming a space at the bottom of the battery, the electrodes of said battery supported by said partition, and terminating below the top of the battery vessel to form a space thereat, and tubes or openings affording free communication between said spaces at the top and bottom of the battery. (7) The combination, substantially, as hereinbefore set forth, in a secondary battery, of the battery vessel, the electrodes of the battery terminating at top, so as to leave a space for the collection of the surplus gases generated in the battery, and vertical tubes or spaces extending through the electrodes to facilitate the collection of the gases in the space at the top of the battery.

2619. IMPROVEMENTS IN APPARATUS CONNECTED WITH ELECTRIC LIGHTING, *R. E. B. Crompton, London.*—3*rd June*, 1882.—(*Not proceeded with.*) 2*d*.

This relates to arc lamps, and to the regulation of both carbons by means of pulleys and cords, &c.

2618. IMPROVEMENTS IN DYNAMO-ELECTRIC MACHINES, *R. E. B. Crompton, London.*—3*rd June*, 1882. 6*d*.

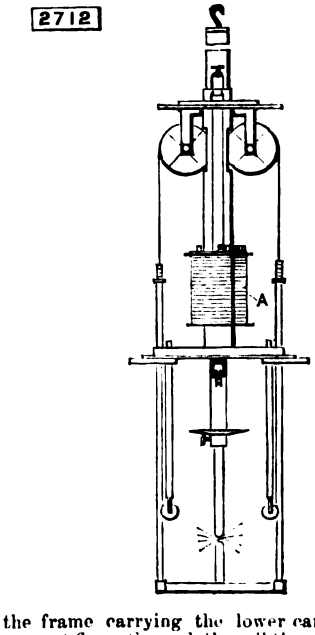
This relates to an improved method of winding disc armatures. The inventor divides the disc into as many segments as there are intended to be separate coils, and on each segment he winds as many equal and parallel turns of wire as its inner circumferential width will admit of; he



then continues the winding through a series of holes pierced through the disc, or steps cut in the segments, in such manner that each successive turn is shorter than the one preceding it. In this manner he fills up the otherwise unoccupied triangles with winding in a series of turns arranged stepwise, as shown in the accompanying figures.

2712. IMPROVEMENTS IN ELECTRIC LAMPS, *W. R. Lake, London, 9th June*, 1882.—((*A communication from F. Krizik and L. Piette, Pilsen, Austria*). 6*d*.

This relates to an improved means of regulating the arc. The upper carbon is attached to an iron core, thick at the bottom, but tapering to a point at its top, which works in and is the core of electro magnet A. This core is also connected by the pulleys and cords, shown in the figure, to



the frame carrying the lower carbon. When a current flows through the coil the core is attracted upward and the arc struck, and the balance between the attractive force of the coil and the weight of the frame carrying the lower carbon equalised. As the arc increases the current weakens, and the weight of the iron core overcomes the attraction of the coil sufficiently to let the carbons approach so as to again equalise the balance.

2674. IMPROVEMENTS IN ELECTRIC ARC LAMPS, *E. de Pass, London.*—7*th June*, 1882.—(*A communication from J. Gloker, Paris.*)—(*Not proceeded with.*) 2*d*.

This relates to an arc lamp, in which the upper carbon is regulated by means of two solenoids and an armature.

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SLIP

POSTAL TELEGRAPHS.—Mr. J. Samuel, sorting clerk and telegraphist at Swansea, has been appointed Postmaster of Arundel.

LEWISHAM.—The Lewisham District Board of Works have retained Mr. Shoolbred, electrical engineer, to advise them in the matter of provisional orders.

BIRMINGHAM AND WARWICKSHIRE BRUSH ELECTRIC LIGHT COMPANY.—Mr. T. H. Seymour Hawker has been appointed electrician to this company.

SOUTH EASTERN RAILWAY TELEGRAPHS.—Mr. William Leonard has been appointed to succeed the late Mr. C. V. Walker as superintendent of telegraphs on this line.

AN EXHIBITION AT ZURICH.—A national exhibition is to be held at Zurich, in Switzerland, this year. Telegraphy, telephony, and other applications of electricity will be represented.

ELECTRIC LIGHTING AND SUGAR PLANTERS.—It is stated that some of the sugar planters in the Hawaiian Islands are now utilising electric lights to enable them to cut their cane at night.

CHANNEL ISLANDS.—The cable to Guernsey is interrupted. Telegrams for Jersey have, therefore, to be wired either by way of France, or forwarded by steamer to Guernsey, and thence by cable.

SIAMESE TELEGRAPHS.—News from Marseilles says that the "Irrawaddy" has left with eight French telegraphists for the King of Siam, who intends to establish a telegraphic station at Bankok.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended Jan. 15 were £2,118, as compared with £2,188 in the corresponding period of 1882.

CABLE REPAIRED.—The Eastern Telegraph Company notifies the restoration of the Porthcurnow-Vigo cable, which was interrupted last week, thus restoring this company's duplicate means of communication with the Peninsular.

GENEROSITY.—Dr. Stephan, the German Postmaster-General, has received a remittance of 200gs from the Indo-European Telegraph Company, as a subscription to the fund now being raised on behalf of the victims of the late inundations in the Rhine districts.

MESSRS. W. GLOVER AND CO.—We are informed that this well-known Manchester firm of wire manufacturers have opened offices at 28, Budge-row, Cannon-street, London, E.C., under the charge of Mr. A. L. Craig. Their telephone exchange number is 1,784.

THE WHEATSTONE SYSTEM IN FRANCE.—This system, which has recently found such favour in the eyes of American telegraphists, is now to be introduced on French lines. Operators are being sent from the provinces to Paris to learn how to manipulate the apparatus.

VIBERT V. EASTERN TELEGRAPH COMPANY.—This case, which was for wrongful dismissal, was tried at the New Law Courts on the 25th inst., with the result that a verdict for the defendant Company was found, on the ground that plaintiff had received sufficient notice.

ELECTRIC EXHIBITION AT PHILADELPHIA.—The Engineers' Club, of Philadelphia (U.S.A.) have suggested the advisability of holding an exhibition of the progress and products of modern electric engineering. The matter has been referred to the Board of Directors.

THE TELEPHONE IN PARIS.—Besides its ordinary working lines, the Société Générale des Téléphones has established, since its formation in 1880, 200 private lines and more than 2,000 telephonic posts, in Paris and the provinces. M. Hospitalier is our authority for this statement.

POSTAL TELEGRAPH ENGINEERS.—The clerical staff and inspectors of the Divisional Engineer, Metropolitan District, held their annual dinner at the New Gresham, on Monday evening last. About forty persons were present, Mr. H. Eaton, the head of the branch, presiding.

"GREAT SUN SPOTS."—An interesting article on this subject appeared in *The Times* of Tuesday. The writer referred to the now little doubted connection between sun spots and the phenomena of terrestrial magnetism, first indicated by Sabine, and alluded to the disturbances of 1859.

ELECTRIC LIGHTING AT MONTREAL (CANADA).—Describing the opening of the Ice Carnival at Montreal, the correspondent of a daily paper describes the city as being "brilliant with electric lights" at night time. We can quite imagine that the arc lights would look at their best in the court of King Frost.

"L'ELECTRICITE."—Our Paris contemporary, *L'Electricité*, has taken a new lease of vitality with the new year, and now appears better printed, on better paper, and in better garb altogether. We congratulate our contemporary upon its present appearance, and hope that the new year may increase its prosperity.

"WHOLESALE ELECTRICITY."—This is the somewhat novel title of an article in last Monday's *Times*. The writer gave a brief review of the plan upon which Mr. Moulton has drawn up the provisional orders, which were entrusted to his care. As we have already treated this subject in our columns we need not refer to it at any length here.

ELECTRIC LIGHTING AT BOLTON (LANCS.).—The first permanent installation of incandescent lighting in Bolton took place on Monday, the 22nd inst., at the cotton mills of Messrs. Haslam and Co. The dynamo used is one of Siemens's shunt-wound machines, and the lamps are Swan's 20 c.-p. The installation has been carried out by Mr. William Banks, electrician, of Corporation-street, Bolton.

ELECTRIC LIGHTING IN SOUTHWARK.—The St. Saviour's District Board of Works, Southwark, after careful consideration of the draft provisional order now being applied for by the Metropolitan Brush Electric Light and Power Company has resolved not to offer any opposition to the granting of the same by the Board of Trade. This is the first instance of the kind under the Electric Lighting Act, at least in London.

ELECTRIC LIGHTING IN BRISTOL.—A wholesale and retail grocer, Mr. R. S. King, of West-street, St. Phillip's, Bristol, has adopted the electric light for the illumination of his shop and warehouse. Forty-five Swan incandescent lamps are employed, the current being supplied by an S.D. 7 Siemens dynamo, driven by a 4 h.-p. steam engine. The switches and fittings were supplied by Mr. H. E. Kear, of Redcross-street, Bristol.

THE MUNICH EXHIBITION.—We have received an official document of thanks from the committee of this exhibition, which is very neatly got up. It contains an illustration of the interior of the "Glas Palatz," where the exhibition was held, with an ornamental cover, and is signed by the members of the committee. This document will be appreciated by English journals as a courteous acknowledgment of their services by our fellow workers in Germany.

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THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—On Wednesday week the Streets Committee of the Commission of Sewers visited the works of this company at Greenwich, and were met by Mr. Willoughby Smith, the electrician. The works are now open day and night for the purpose of making the Red Sea cable, and are wholly lighted with the Swan incandescent light. The committee were much interested in Gordon's large dynamo, which we illustrated and described in a recent issue.

ELECTRIC LIGHTING FOR CANTERBURY.—The question of the introduction of the electric light into this city, which has for some time engaged attention, was again the subject of debate on Wednesday last. The Town Council held a long consultation with the managing director and solicitor of the South Eastern Brush Company, but the consultation was unsuccessful, and the parties separated without coming to terms. A special meeting of the council was afterwards held, at which it was decided that in order to protect the city from monopoly a number of the clauses in the provisional order for which the company is about to apply should be opposed.

ELECTRIC LIGHTING IN COLLIERIES.—We recently mentioned that Messrs. Bell Brothers had adopted incandescent lighting for their Page Bank Colliery in South Durham. The whole of the lights were successfully started last week. They are worked on two circuits—"the long-hour," or all night, and the "short-hour," or day circuits, comprising 37 and 64 Maxim incandescent lamps respectively. The current is supplied by two dynamos. Messrs. Harle (manager) and Clough (engineer to the colliery) have also had a few lamps fitted in their houses. The work has been carried out by the Maxim-Weston Electric Company, of 47, Cannon-street, E.C.

ELECTRIC LIGHTING AT THE HOLBORN RESTAURANT.—The Holborn Restaurant, which has been thoroughly remodelled and enlarged, will, when opened, be lighted by the Edison electric light. Messrs. Ransomes, Head, and Jefferies, of the Orwell Works, Ipswich, are building for this purpose two 16 horse-power engines, to be fitted with their patent automatic governor expansion gear, which has already given such excellent results in connection with the electric light. The whole arrangements are under the immediate control of Messrs. Lewis Olrick and Co., of 27, Leadenhall-street, E.C., consulting engineers to the Edison Company. The opening of this new installation, will, we understand, take place early in February.

ELECTRIC LIGHTING FOR THE CITY.—The Select Committee of the Commissioners of Sewers of the City of London are inviting proposals for lighting (only) portions of the City by means of electricity, with a view to applying to the Board of Trade for a license under the Electric Lighting Act, 1882. Each proposal must indicate on a plan the area or areas intended to be lighted, together with conditions of supply, including price, &c. No one area is to exceed an eighth of the whole city. The proposals must include the lighting of the public streets and private and other premises within the respective areas, and be subject to the provisions of the above-mentioned Act and the rules made by the Board of Trade. Proposals should be sent to Mr. Hy. Blake, principal clerk, Sewers Office, Guildhall, E.C., by the 3rd of February.

ELECTRIC LIGHTING AT BERECHURCH HALL.—During the week several letters have appeared in *The Times* referring to the lighting of Mr. Coope's mansion at Berechurch. "Enquirer" set the example by asking sundry questions as to whether it was necessary to start the engine before you could get one light, and whether you had to run it all the same if one or 200 lights were going, and more to the same effect. This Mr. Coope answered in the affirmative. Mr. Sellon contributed to the correspondence by advocating the use of secondary batteries, by means of which the constant running of the engine might be avoided and perfect steadiness of the lights ensured. In another issue of the same paper, Mr. F. Rogers asked Mr. Sellon to state "the cheapest and best plan of electrically lighting, say, a pair of semi-detached houses of the villa class."

ANGLO-AMERICAN ELECTRIC LIGHT COMPANY.—A notice in the *Gazette* of January 19 states that "in pursuance of Section 142 of the Companies' Act, 1862, a general meeting of the members of the above-named company will be held at No. 112, Belvedere-road, Lambeth, Surrey, on Wednesday, the 21st day of February, 1883, at four o'clock in the afternoon, for the purpose of having an account laid before them, showing the manner in which the winding up has been conducted, and the property of the company disposed of, and of hearing any explanation that may be given by the liquidator, and also of determining, by extraordinary resolution, the manner in which the books, accounts, and documents of the company, and of the liquidator thereof, shall be disposed of." This company must not be confounded with the Anglo-American Electric Light Corporation.

ELECTRIC LIGHTING AT SHEFFIELD.—We have received a copy of the report of Mr. Conrad W. Cooke, the consulting engineer, who was recently requested by the Corporation of Sheffield to advise them with respect to the carrying out of their provisional order. The space at our disposal this week will not permit of our printing this report, but we shall hope to give it in a future issue. As a somewhat erroneous impression is abroad concerning what Mr. Cooke really did advise, we extract the following sentences:—"I have in the earlier part of this report recommended the employment of electric lighting by incandescence for the *private* lighting of the district for the reasons already adopted. It must, however, be a matter for the subsequent consideration of the Corporation whether it will be advisable on their part or not to recommend to consumers the employment of any one system of incandescence lighting or special form of lamp."

JOINT STOCK COMPANIES.—The *London Gazette* for the 23rd inst. contains a long list of joint stock companies that were struck off the register at Somerset House on that date. It includes the following amongst others:—Electro-magnetic and Electro Plate Company, Gas Engine Electrical Apparatus Company, Ocean Telegraph Company (registered on 1st April, 1865), Railway Electric Engineering and Telegraph Works Company, Scottish Pilsen-Joel and General Electric Light Company, Telegraphic News Association, and the Universal Telegram Company (registered 28th Oct., 1864). Another notice in the same *Gazette* states that the following companies will be struck off the register at the end of three months from the above date, unless cause is shown to the contrary:—Allan's Transatlantic Telegraph Company, Economic Telegraph Company, Finsbury Telegraph Newspaper Company, Great Northern Electric Light Company, Oriental Telegraph Company.

LIPMANN'S CAPILLARY ELECTROMETER.—At the last meeting of the Glasgow Philosophical Society, Dr. M'Kendrick read a paper entitled "Note on a Simple Form of Lipmann's Capillary Electrometer." This instrument consists of a fine capillary tube containing mercury and dilute sulphuric acid so placed under a microscope as to show a junction of the metal with the acid. A fine platinum wire dips into mercury at each end of the tube, and feeble currents, or rather slight differences of potential, at once cause

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a movement of the mercurial column. The form made by Dr M'Kendrick is simply a tube drawn out into a capillary and bent up at the ends, but it is extremely sensitive, showing the currents obtained from muscle, and other feeble currents known to physiologists. Specimens of the instrument were shown, and the oscillations of the mercury, magnified by a quarter of an inch objective, were projected on the screen by the lime light, so as to be visible to all present. Dr. M'Kendrick illustrated the sensitiveness of the instrument by various experiments.

INSTITUTION OF CIVIL ENGINEERS.—The council of this institution have arranged for the delivery at their rooms, in Great George-street, S.W., of a series of six lectures, on the applications of electricity, on the undermentioned Thursday evenings, at 8 o'clock:—Feb. 15, "The Progress of Telegraphy," by Mr. W. H. Preece, F.R.S., M. Inst. C.E. March 1st, "Telephones," by Sir Frederick Bramwell, F.R.S., V.P. Inst. C.E. March 15th, "The Electrical Transmission and Storage of Power," by Dr. C. William Siemens, F.R.S., M. Inst. C.E. April 5th, "Some Points in Electric Lighting," by Dr. J. Hopkinson, F.R.S., M. Inst. C.E. April 19th, "Electricity Applied to Explosive Purposes," by Professor F. A. Abel, C.B., F.R.S., Hon. M. Inst. C.E. May 3rd, "Electrical Units of Measurement," by Sir W. Thomson, F.R.S., M. Inst. C.E. Admission to these lectures will be as to the ordinary meetings of the institution, that is to say, members, associates and students will have the right of personal admission, and every corporate member will have the privilege of introducing one friend.

THE TELEPHONE IN MEXICO.—The Mexican Telephone Company was formed in New York on the 21st April, 1882, with a nominal capital of 1,000,000 dollars, in 10 dollar shares. It owns the exclusive rights of the instruments used by the American Bell Telephone Company and the Continental Telephone Company for Mexico. The company possesses and works the telephonic exchanges of Mexico and Guadalajura, and is constructing public and private lines in the States of Mexico and Jalisco. The remainder of the country is to be apportioned between sub-companies, of which the following have already been organised:—The Mexican Central Telegraph and Telephone Company, the Mexican Northern Telegraph and Telephone Company, the Mexican Pacific Telephone Company, the Chihuahua Telephone Company, the Durango Telephone Company, the Puebla Telegraph and Telephone Company, the Vera-Cruz Telegraph and Telephone Company. Installations have commenced in eighteen of the principal towns in Mexico.—*Bulletin de la Compagnie Internationale des Telephones.*

ELECTRICAL SAFETY LAMP FOR MINES.—A correspondent, in a recent issue, asked for some information concerning the premium that has been offered by Mr. Lever, M.P., for a portable electric safety lamp for use in mines. For the benefit of our correspondent and others, we may say that Mr. Ellis Lever's address is Culdeth Hall, Bowdon, Cheshire, and that he has agreed to hand over £500 to the Central Board of the Miners' National Union, to be paid to any one inventing such a lamp. It has been provided that the offer shall remain open throughout the current year, and that the adjudicators shall be composed of "three scientists, one to be selected by Mr. Lever, one by the Council of the Royal Society, and one by the Council of the Society of Arts, one person representing the mining engineers, chosen by themselves, and one person representing the workmen, chosen by the Central Board of the Miners' National Union." The above-mentioned reward is to be meanwhile invested in the names of three trustees, one of whom shall be Mr. Thomas Burt, M.P., the other two to be chosen by the Miners' National Union.

"THE OPERATOR."—Our New York contemporary, which has hitherto been known under the title of *The Operator*, has with the New Year adopted a longer and more comprehensive appellation. In future it will be known as *The Operator and Electrical World.* Concurrently with its assumption of an extended heading we find that it has enlarged its size. In its issue for the 6th inst., our contemporary extracts Mr. Smillie's first letter to us on microphonic contacts, and alludes to it as challenging the statements in Professor Blyth's paper in the *Proceedings of the Royal Society of Edinburgh*, which paper *The Operator* says it reproduced from the *Proceedings* of the above-mentioned society. The same paper, we may remark, was also published in *The Electrician* prior to its publication in *The Operator*, and it is a remarkable instance of how men's minds in different quarters of the globe may conceive and carry out the same thought, that when the issue of *The Operator* containing the above paper came to hand, we found that their engraver had made identically the same mistake in his woodcut that ours had. Here we have a fit subject for the investigation of the recently formed Psychical Research Society.

ELECTRIC LIGHTING IN LONDON.—The Electric Lighting Committee of the Strand Board of Works intend to formulate some conditions with reference to the introduction of electric lighting into their district, which are shortly to be laid before the Board of Trade. The conditions are somewhat as follow:—That only one company should come into the district; that it should light all the district; that any private person desiring a separate service might do so on arranging with the company; that the board should control the number of hours during which the lighting should be maintained; that the charges should be 10 per cent. on the capital employed.—It was suggested at the meeting at which these conditions were submitted, that the committee should be empowered, if necessary, to obtain the services of an electrical expert at a cost not exceeding 25 guineas.—St. Olave's Board of Works do not think it advisable to take any steps to obtain a license.—St. George the Martyr (Southwark) Vestry have contented themselves with drawing up a formal list of amendments which they will like carried out in the provisional order applied for by the Metropolitan Brush Company.—St. Luke's Vestry also require some amendments in the same company's order.

ELECTRIC LIGHTING IN CARDIFF.—The Great Western Electric Light and Power Company have established a station in Working-street, Cardiff, where they have established two engines of 60 horse-power each. The premises of the *South Wales Daily News* have been lighted by means of Brush arc lamps erected by this company. They have also recently lighted up the Commercial Dry Dock at Cardiff, for the Tyneside Engine Works, with 16 Brush lamps, the dynamo being driven by one of Marshall and Co.'s portable engines. The work was carried out, under the personal superintendence of Mr. Philip Jolin, M.I.C.E., managing electrician to the company, by Mr. Ballard, the head superintendent from Bristol. The lights are placed in and about the ss. "Rumney," now under repairs. We are told that the lighting is satisfactory, and much appreciated. With reference to the dispatch with which this latter work was carried out, we may mention that the order was only received at the company's station in Bristol on Thursday afternoon, the 11th inst, and that the dynamo machine was packed and left Bristol on Friday; the work of installation was begun on

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Monday morning, the 15th inst., at 1 a.m., and the lights were running on Tuesday, the 16th, at 6 p.m., everything having been fixed by that time.

A New Electrical Machine.—The old frictional machines for producing electricity of high tension are now being largely superseded by others of the induction type. One of these, the Voss machine, has of late come into well-merited popularity. The compound plate induction machine of Mr. James Wimshurst also gives excellent effects. This gentleman, however, has now produced another machine which is remarkably simple as well as powerful, says *The Times*. Two circular discs of ordinary window glass 14½in. in diameter are mounted about one-eighth of an inch apart on a fixed horizontal spindle, and rapidly rotated in opposite directions by turning a winch-handle below. Both plates are well varnished, and have 12 radial sector-shaped pieces of thin brass attached at equal intervals on their outer surfaces. The two sectors on the same diameter of each are twice in each revolution momentarily touched by two fine wire brushes at the ends of a curved metallic rod. The fixed conductors consist of two forks in a horizontal position, with collecting combs directed towards each other and towards the two discs which rotate between them. To these combs are attached the terminal electrodes, which have ebonite handles, and may be shifted more or less apart. The apparatus can be made for a few shillings.

Electricity at the Birmingham and Midland Institute.—Our correspondent sends us the following:—"The annual *conversazione* of this institution, extending over four evenings, was illuminated by Swan's incandescent lights, and electricity filled other important parts in the programme. The current was supplied by Messrs. Winfield and Co., from the Cambridge-street works, and the lighting of the Town Hall was precisely the same as on the occasion of the Musical Festival, when we gave a full description of the installation. A lecture was given each evening by Mr. Woodward, of the institute, illustrating the various applications of electricity to domestic uses, as also for lighthouse purposes. The electric light exhibited in great perfection a set of polariscope objects lent by Mr. Spottiswoode, probably the finest set in existence, among them a unique twin crystal of right and left-handed quartz. Of course, these objects were brought out with a brilliancy of colour and a magnitude rarely to be seen. But the illustration which evidently most thoroughly met the general taste was a large fountain fitted up on the platform, and throwing a great body of water nearly to the roof of the lecture theatre. This was illuminated from above through an opening in the ceiling by a powerful arc lamp, producing a succession of varying colours by interposed glasses. The effect was magnificent, especially when two or three stripes of colour were thrown on the moving and changing masses of water; it was not so pleasing upon the faces of the audience when a particular shade of green gave them the appearance of an assembly of the dead. Messrs. Winfield and Co. have succeeded in showing that it is possible to maintain a perfectly steady light hour after hour. The whole of the lights filled the hall with unwavering radiance, and without even a momentary flicker."

Electric Lighting of Workshops.—The French papers of last week give descriptions of a large installation of incandescent and arc lamps that has been carried out at the Railway Waggon Works of Saint Denis. Ten Weston arc lamps and twenty-four Maxim incandescent lamps are employed. The total horse-power available in the workshops is sixty, but of this about fifty is absorbed by the various machines in use, leaving, therefore, only ten for electric lighting purposes. By means of accumulators, however, which are charged during the day by a continuous current Weston dynamo driven with the balance of horse-power available, the difficulty is overcome. The incandescent lamps are fed from the accumulators in the evening, and the dynamo current used during the day for charging the accumulators is available at night for the arc lamps. The accumulators used are those known as the Kabath, with corrugated plates, and 80 of these are employed. It being necessary to shift the incandescent lamps from time to time, as the work in hand may require, the following arrangement has been adopted:—Pairs of naked copper wires are stretched from end to end of the workshops, and connected with the accumulators. On these wires small runners are placed, one on the positive, and the other on the negative wire, and a pair for each lamp; a copper tube, with two horizontal arms at its upper end, these latter being fixed to a pair of runners, suffice to carry the conducting wires to the lamp, which is thus suspended at a convenient distance from the ground. By means of a pole it is easy for a workman to push the whole arrangement any distance he may require along the two copper wires, and transfer the light from one spot to another. Several of these pairs of wires are arranged in parallel lines up and down the workshop at a convenient distance from each other. The whole of the work has been carried out by M. Ch. Farquhar, for M. De Kabath, of Paris.

Birmingham Telegraph Messengers.—A meeting of the messengers employed at the Birmingham Telegraph Office was held last week in the letter-carriers' coffee room of the Post Office. Mr. S. Walliker, the postmaster, presided, and there was a large attendance, the company including the mayor and others. The chairman said the object of the meeting was to encourage the telelegraph messengers in the pursuit of useful knowledge and the profitable employment of their leisure hours. The chief merit in a telegraph messenger consisted in the rapid delivery of messages and in the rapid return of the messenger to the office; and in order that the boys might be encouraged to exert themselves in that respect every minute that was lost was marked down against them; then, at the close of the year, the marks were added up, and the boy that had lost the least amount of time was the boy that stood highest in the merit list. During the past year, a boy named Jeffcott headed the list, he having lost only twenty-four minutes, and he was also the first boy in the previous year's list. The general conduct of the boys was remarkably good. It was very rare now that any were taken before him for misconducting themselves. When he first became postmaster as many as twenty at a time were brought before him, but now it was rare to have three at a time. In order that the boys might have an opportunity of improving their minds he gave them several essays to write on different subjects, and some of the papers were very fairly written. The boys had also sent in some coloured sketches, several of which possessed great merit. Other subjects for essays had also been given, and the prizes for those, as well as for essays already written, and the sketches, would be awarded to successful competitors on the Queen's birthday. Prizes would also be given for proficiency in shorthand, for general good conduct, &c. In the course of the evening the mayor announced his intention of giving three prizes to be competed for by the boys. Mr. S. Walliker is to be congratulated on the good results that have attended his scheme in the past, and we wish him all success for the future. His excellent example might well be imitated in other towns.

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THEORY OF MAGNETO AND DYNAMO MACHINES.

XXII.

Summary of last Article.

A given machine has a certain ratio between the resistance of the field magnet wire, b, and that of the armature, a, which is very important, and which we may call the *characteristic ratio* of the machine, and denote by m. One result of the last article was the proof that for high efficiency m must be large, the larger the better.

It will be convenient to write some of the more important expressions of the last article in terms of this characteristic m, or $\frac{b}{a}$.

The "waste ratio" which is given in equation (xiii,), for instance, and which we will now denote by λ, becomes

$$\lambda = \frac{r}{b} + \frac{1}{m}\left(\frac{r}{b} + 2 + \frac{b}{r}\right) \quad . \quad . \quad . \quad . \quad . \quad (xiii)'.$$

N.B.—There is a misprint in equation (xiii.) of last article, p. 78, Dec. 9, an index 2 having dropped from the brackets. The equation should read—

$$\text{waste ratio} = \frac{\text{waste}}{\text{useful}} = \frac{r}{b} + \frac{a}{r}\left(1 + \frac{r}{b}\right)^2 \quad . \quad . \quad . \quad (xiii.).$$

The efficiency f is connected with the waste ratio by the simple equation

$$f = \frac{1}{1 + \lambda}.$$

The most economical value of the external resistance is

$$r = \frac{b}{\sqrt{(1 + m)}}, \quad . \quad . \quad . \quad . \quad (xiv.)'$$

and hence the least possible waste ratio for the given dynamo is

$$\lambda_1 = \frac{2}{m}\left\{1 + \sqrt{(1 + m)}\right\}; \quad . \quad . \quad (xv.)'$$

or, what comes to the same thing, the maximum efficiency is

$$F = 1 - \frac{2}{m}(\sqrt{1 + m} - 1). \quad . \quad . \quad . \quad (xvi.)'$$

Numerical Examples of the Maximum Efficiency of Shunt Dynamos.

As a first example, take a small Siemens D_5 dynamo, with armature resistance $\frac{1}{2}$ an ohm, and field magnet resistance $7\frac{1}{2}$ ohms. Here the characteristic of the machine is 15, which for high efficiency is by no means great enough.

The best value of the external resistance is

$$\frac{7{\cdot}5}{\sqrt{16}} = 2 \text{ ohms nearly.}$$

The least possible waste ratio is

$$\frac{2}{15}(1 + 4) = \frac{2}{3},$$

or the highest possible efficiency

$$= 1 - \frac{2}{15}(4 - 1) = 1 - \frac{2}{5} = \frac{3}{5} = 60 \text{ per cent.}$$

To determine the best arrangement of incandescent lamps: suppose each lamp is a 16-candle Swan, with a resistance of about 28 ohms. If it has only 14 lamps to work, they should be all abreast, in order that their combined resistance may be 2 ohms. This is about what a D_5 machine can thoroughly do.

If the machine could work 56 lamps they ought to be arranged 28 abreast and 2 in series. For intermediate numbers one has to do the best one can, but one cannot hit exactly the most economical value of the external circuit resistance.

Next consider a z machine with the armature resistance $\frac{1}{8}$ ohm, and the field magnet 50 ohms, so that $m = 400$; this is much better.

The best value of the external resistance is $2\frac{1}{2}$ ohms. The least possible waste ratio is $\frac{21}{200} = {\cdot}105$; or the highest efficiency is $\frac{181}{200} = 90{\cdot}5$ per cent.

Suppose this machine had to excite Edison lamps of 70 ohms each: 30 would be best arranged simply abreast; 120 should be 60 abreast, and two in series; 270 should be 90 abreast, and three in series; 480 ought to be 120 abreast, and four in series; and generally the number abreast ought to be 30 times the number in series, in order that the external resistance may be $2\frac{1}{2}$ ohms and the highest efficiency attained.

We may summarise then thus:—For any given machine of which the best external resistance is r, to arrange a given number, N, of similar things, such as incandescent lamps, secondary batteries, or anything of which the external resistance may be said to be R ohms apiece; they should be arranged as nearly as possible so that the number abreast is $\sqrt{\left(\frac{N\,R}{r}\right)}$, and the number in series is $\sqrt{\left(\frac{N\,r}{R}\right)}$.

Examples of Efficiency in other cases.

The efficiency calculated above for the two machines is in each case the best possible, but suppose the external resistance r is not at its most economical value (xiv.), but is, say, $\frac{1}{2}$ ohm., or 10 ohms., what are the efficiencies then?

The small machine with the characteristic 15 will for $r = \frac{1}{2}$ have a waste ratio $\frac{18}{15}$, and accordingly an efficiency of $\frac{15}{33}$, or $45\frac{1}{2}$ per cent.

When $r = 10$, on the other hand, its efficiency will be $38\frac{1}{2}$ per cent.

Showing that it is better to have the external resistance $\frac{1}{8}$th too small than five times too big.

Next try the machine with the characteristic 400. When $r = \frac{1}{2}$ its efficiency is 79 per cent, and when $r = 10$ its efficiency is 82; but if $r = 20$ ohms the efficiency is only 66 per cent.

The general law as to whether, if the most economical value of the external resistance cannot be exactly hit, it is better to make it too small or too big is evident from (xiii.)' and may be thus expressed.

A value of the external resistance, which is a sub-multiple of the most economical value, will give a higher efficiency than if it were the corresponding multiple. But if the external resistance has to differ from the most economical value by a fixed amount, it is better that the difference should be in excess than in defect.

The following curve exhibits the waste ratio of a given shunt machine for every possible value of the external resistance.

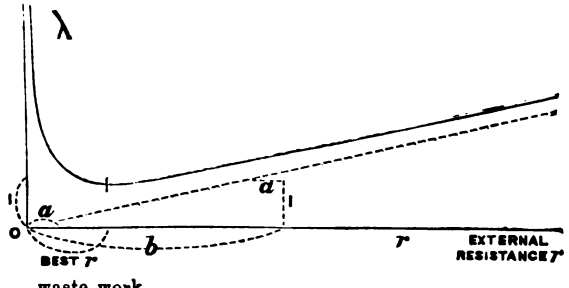
The curve is simply a hyperbola with the two asymptotes, $r = o$, and $\lambda = \frac{a + b}{b^2} \cdot r$.

When r is small it nearly coincides with the hyperbola $r\lambda = a$.

When the external resistance equals the armature resistance, or $r = a$, $\lambda = 1 + \frac{3a}{b} + \frac{a^2}{b^2}$;

when the external resistance equals the field magnet resistance, or $r = b$, $\lambda = 1 + \frac{4a}{b}$;

and when $r = nb$, $\lambda = n + \frac{(n + 1)^2}{n} \cdot \frac{a}{b}$.



Curve of $\frac{\text{waste work}}{\text{useful work}}$ for a given shunt dynamo, for different amounts of resistance in the external circuit. The curve is drawn for the particular values $a = \frac{1}{2}$, $b = 5$. The best r accordingly is 1·5, and here the ordinate of the curve has its minimum value ·863; which corresponds to an efficiency of 53·7 per cent.

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CROMPTON'S COMPOUND MACHINE.

BY GISBERT KAPP.

(CONCLUDED FROM PAGE 202.)

In designing a new machine its leading dimensions are determined by the maximum of electrical work it will have to perform. Whether it is to be compounded or not, to satisfactorily do that work the armature must contain a certain number of coils of a given size of wire, and the pole pieces, arms and yokes of the field magnets must be of a certain size and shape, all as experience teaches. The only point left to be determined is the way the field magnets are to be wound. The graphical method for expressing the relation between exciting power and electromotive force, although it does not give rules for determining straightway and at one operation the best dimensions and number of magnet coils, enables us to judge whether a given arrangement be suitable for the particular purpose required. It is therefore necessary to first assume more or less arbitrarily a certain way of winding, and then to investigate by the graphical method the behaviour of the machine thus wound. If the result be unsatisfactory, the diagram will show where the defect lies, and the winding must be altered accordingly, until repeated investigation shows that the best possible arrangement has been found.

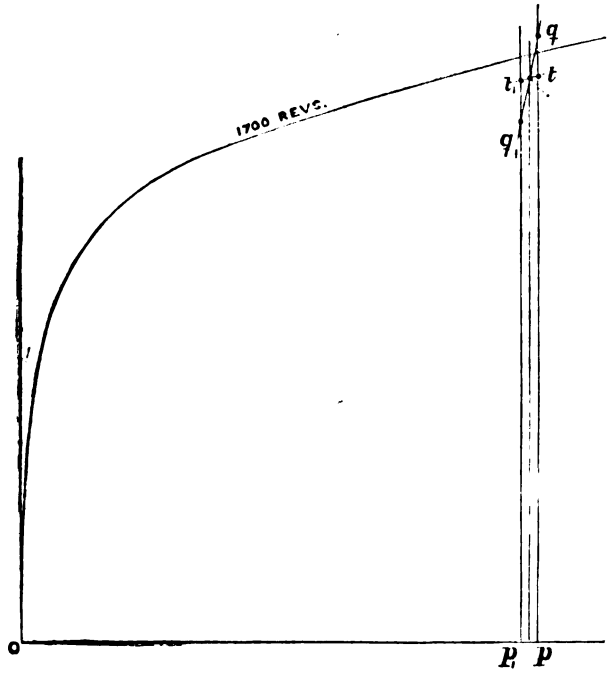

FIG. 7.

The abscissæ in Fig. 7 represent exciting power in ampere turns on one arm of field magnets, a hundred ampere turns being equal to one millimetre. The ordinates represent corresponding electromotive force in armature if no current is allowed to flow through it. One volt equals one millimetre. This curve is not the characteristic curve as usually understood; it corresponds to the dotted line in Fig. 6 (p. 201) with this exception, that in Fig. 6 the abscissæ represent exciting power and external current at the same time, while here they represent only exciting power. It matters nothing whether this is derived from the shunt or the main or from both; the electromotive force is simply a function of the total number of ampere turns.

In Fig. 8 the line O A represents the resistance of armature. For the sake of simplicity it is shown as a straight line, although in reality it is slightly curved downwards, owing to the fact that with an increase of current through the wire its temperature, and, therefore, its resistance, are also slightly increased. The difference is, however, too minute to be shown in a small-scale diagram.

$$R = \text{tan. A O X.}$$

To drive a current O e through the armature, an electromotive force equal to ea is necessary. Introducing our former symbols, we have

$$E a - E b = e a.$$

Similarly, O L represents the resistance of main exciting coils and line, $c k$ being the electromotive force necessary to drive the current O c through it.

$$E b - E l = c k.$$

The resistance of shunt coils is represented by the line O s.

$$\rho = \text{cotan. Y O } s.$$

If the electromotive force at the brushes be O f the current it will drive through the shunt is represented by the length $f g$, the scale of the diagram being, as before, 1 volt and 1 ampere equal one millimetre. The exciting power of main

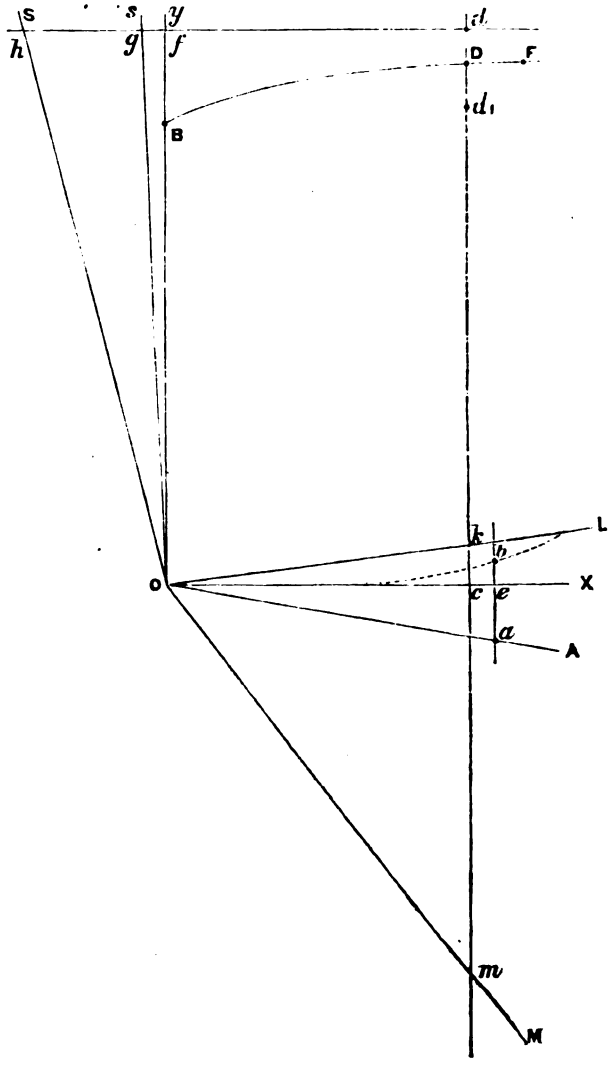

FIG. 8.

coils being proportional to the product of number of turns and external current, the ordinates of the straight line O M will give main-ampere-turns if the tangent of angle M O X be equal to the number of coils employed, the same scale as in Fig. 7 being, of course, used. In the same way the shunt-ampere-turns can be represented by the straight line O S, the tangent of angle S O Y being equal to number of shunt coils divided by the resistance of shunt

$$\text{tan. S O Y} = \frac{v}{\rho}.$$

From this equation it will at once be seen that the exciting power of the shunt cannot be increased by piling more wire on to it, for in the same ratio as the turns are multiplied the resistance is also increased, and hence the quotient $\frac{v}{\rho}$ remains unchanged. This holds good within certain limits,

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but if too much shunt wire is used its efficiency will actually be reduced, for not only do the outer coils on account of their greater length offer more resistance than corresponds to their number, but being farther removed from the magnet core, their magnetising power is also at the same time lessened. On the other hand, a large number of shunt coils tends to economise current.

The dotted line in Fig. 8 represents the difference of electromotive force in the armature with a current passing and without it, as explained in the last article (see Fig. 6 on page 201). If a current O e be permitted to flow through the armature its electromotive force will, other things being equal, suffer a reduction $e\,b$ as compared to the electromotive force if no current passes. The curve representing this reduction must be found experimentally in the manner explained in the last article.

Our problem now stands thus:—Given an external current O c, we desire to know what electromotive force between lamp terminals it will have. The first step towards solution of this problem must be a guess at the external electromotive force; say we assume it to be $k\,d$. By drawing a horizontal through d (or, in the case of the shunt current being also carried through the main coils, a straight line under an inclination, the tangent of which is equal to the resistance of main coils) we find point f, the distance of which from o represents the electromotive force creating the shunt current $f\,g$. This added to $O\,c$ gives $O\,e$, the total current through armature.

The total exciting power is $c\,m + f\,h$ ampere-turns, which sum in Fig. 7 is represented by the length O p. To obtain an external electromotive force, $k\,d$, the total electromotive force in armature must necessarily be

$$c\,d + e\,a = p\,q.$$

This, however, does not satisfy the condition represented by the curve in Fig. 7. It will be seen that the electromotive force which actually exists in the armature is $p\,t$, this being the ordinate of the curve minus loss $e\,b$. Our first guess has, therefore, been too high. By assuming a lower value, say $k\,d_1$, and, repeating the process, we find the points p_1, q_1, t_1. This time the guess was too low, the real value being between the two. It is in Fig. 7 the point of intersection between the two lines $q\,q_1$ and $t\,t_1$, and in Fig. 8 the point D, which divides $d\,d_1$ in the same geometrical proportion as T divides $q\,q_1$. The electromotive force between lamp-terminals is, therefore, represented by the length k D. It need hardly be mentioned that the accuracy of the result will be the greater the nearer the points $d\,d_1$ are to the real value.

In similar manner E l can be found for other external currents, and thus the curve B D F can be plotted. Absolutely perfect regulation would be obtained if B D F were not a curve, but a straight line parallel to O L. Considering the complicated nature of action and reaction which influence the shape of this curve it is very doubtful whether such absolutely mathematical perfection can be obtained. But, for practical purposes, it will suffice if the curve is very flat, and if its position is nearly coincident with the above-mentioned straight line. Should it be found that deviations exist too great for the safe and steady working of the lamps, it is a sign that the manner of winding was not well chosen. It must be altered until repeated investigation shows a satisfactory result.

ELECTRIC LIGHTING AND BALLET-GIRLS.—The ballet at the Princess's Theatre, Manchester, in which twenty-six ladies take part, has for the past month been danced nightly by the light of small Swan lamps, placed in a flower on each lady's head. The current is supplied by a small battery, the weight of which is about 1½lb., carried on the back of the dancer, as at the Savoy Theatre. None of the ladies are at all frightened, in fact they like it so much that the principal dancer, Miss A. Holt, has arranged to have her dress covered with the lamps, which will be done ere this is in print. The arrangements have been carried out by Mr. H. Bury, of 46, Market-street, Manchester.

THE INDUCTIVE AND CONDUCTIVE CIRCUITS.

II.

BY JOHN T. SPRAGUE.

The two circuits always co-exist, but it is evident that the inductive process precedes the actual conduction, and the step by step induction is, so to speak, the tentative process by which true conductive path, that is to say, the constitution of the true electric conditions, or circuit, is developed. Here the two conceptions of the nature of electricity diverge. All the known facts of electricity show that it is a dual action. All the theories—the two fluid, the single fluid + and —, or the molecular theory, which considers the two electricities, or rather electrifications, as merely the two sides or ends of polarised matter—agree in this. But the mathematical treatment is based upon single and independent actions, and some experimenters have sought to prove the existence of *unipolar actions* such as accord with this treatment. In Fig. 1 we have the picture of such supposed actions. The independent pole +, acting as a radiant point, *induces* polar order in all surrounding matter. In such an action it is clear that each circle will be an *equi-potential line*, with no tendency to side actions, that is, not from any reality in the potential conception, but simply because the force is radial only, and every particle of matter takes up what force its position presents to it. Also every such circle will have equal force acting from it, also radially, and, therefore, the force at each point of each circle will be inversely as the square of its distance from the centre. That is to say, the tension on each molecule in the lines of the field of force thus generated will diminish as the square of its distance.

FIG. 1.

Now, we have a perfect physical analogue of this. Let a smooth plane surface receive a supply of water at its centre, and it will flow outwards in all directions in this exact manner, and its distribution upon and velocity of flow will be identical with the conditions of Fig. 1, in which I have endeavoured to represent the facts by the diminished size and increasing number of molecules as the distance increases.

If we now conceive of some condition which puts this plane surface out of level, the flow of water will at once be altered into an elliptic system, narrowing the more as the inclination increases. If we conceive the plane as perfectly balanced on its centre, any cause which induces the water to tend, however slightly, rather in one direction, will at once cause the plane to cant over, and direct the line of flow more and more in this direction.

Just such an influence we have in electricity. *The second radial system — is always somewhere;* it may be conceived as a second system similar to Fig. 1, but with the direction of the arrows representing the lines of force towards instead of from the centre. Therefore the circles of these two fields must ultimately meet, and when they do the lines of force attract each other with an effect similar to that of tilting the water plane, that is they convert the two supposed independent radial points into the foci of an ellipse, and the imaginary radial lines into the curved lines of a closed field of force. I have endeavoured to show this action in Fig. 2. It is evident here that as soon as the circles of influence cut each other the molecules are subjected to the influence of both foci, generating tension in the same direction. Now, pictorial representation cannot convey directly the well-known fact that the electric force exerts itself in the direction of *most capacity*, and this, as well as the law of inverse squares

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will, therefore, concentrate the action into the space enclosed by the arrows.

This process of induction occurs in the lines of most capacity, or reciprocally of least resistance, and, therefore, if there be a good conductor in the line, that becomes the shortest path, and is represented by the thick line between + and —. Along this line the constant charge and discharge, or molecular interactions, which we call *current*, are propagated. But the external induction is maintained as a condition of static stress or tension, and constitutes the inductive circuit around the conductor, taking a static charge corresponding to the forces exerted at each point, and the capacity of the medium. But, if there is nothing to represent what is ordinarily called a conductor, still there is current; every substance whatever has some conducting capacity, and, therefore, there must needs be a constant transmission of electric current along the lines of force of the inductive circuit—a fact which, while ignored in theory, is practically known to every one who makes an experiment and finds his electric charges gradually weakening.

The direction of the arrows in diagrams of this sort is not merely an aid to the imagination, it represents a physical fact; for, though the forces of the two poles, + and —, are equal, as also the so-called quantity at each, yet there is some real difference in their mode of action. In the discharge it is always found that there are lines of spreading action at the + pole and of concentrating action at the — pole. The brush forms at the + pole, and even when the whole discharge fills an elliptic field it is broadest at the + end, although in vacuum tubes there is commonly a glowing appearance around the negative electrode, which in the highly exhausted tubes of Mr. Crookes is seen to pass into a dark interval.

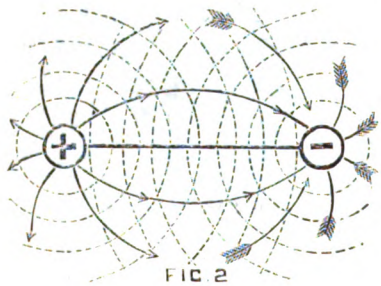

FIG. 2

While on this subject it may be desirable to refer to one of the best evidences ever presented of the independent polar action, or *unipolar discharge*. It is contained in a very interesting paper by Messrs. Spottiswoode and Moulton (*Phil. Trans.*, 1879, p. 165). They connected one end of two vacuum tubes (constituting derived circuits) to the — pole of the coil, and the other ends to a ball fixed at a small distance from the + pole, so that the current was more interrupted and shorter in duration (as due to a spark) than if coming direct from the wire in a closed circuit. The spark selected one tube rather than the other for its proper path, and in the other tube it only produced a glow extending half way along it in a reducing cone. Of this tube they said that the discharge in it is, in fact, one which leaves the + pole and enters the tube, but not with sufficient force to pass through it, and which returns on itself. But the real explanation is most simple, and accordant with the universal facts of electricity. The tubes are not quite equal in resistance, or some accidental circumstance in or around them transforms the partial discharge through one tube into a circuit through and along the glass of the tube itself. The authors took the trouble to prove this without seeing it, for they made a tube with an intermediary electrode connected to one of the end terminals and to the + pole, the other end going to — pole. The circuit might be expected, in this case, to confine itself to the latter half of the tube, but actually two cones formed in the other half, representing opposed unipolar discharges. These are evidently a double derived circuit closed on the glass of the tube. This, also, the authors proved without seeing it. Returning to the two-tube experiment, they attached an external conductor to the + pole, and approaching it to the exterior of the tube just beyond the supposed unipolar cone discharge they drove it back and stopped it. Obviously, they added an external counter force which, preventing the completion of the circuit, prevented also the discharge. The case is precisely like getting a shock from one terminal of a coil, the circuit completing itself through the partially conducting supports, or the current passing into my galvanometer from the one pole of the Voss machine, as described by me in *The Electrician* for January 20th, 1883, page 222. The conclusion of the authors, that each terminal pours forth its electricity to satisfy its own needs, and only in a secondary degree to satisfy the needs of the other terminal, must be exchanged for this other conclusion, according with all the facts of electricity, that as electricity divides among all the paths open to it, each terminal finds its circuit to the other, either directly or indirectly, by conductive or by inductive processes, but that *each takes equal part in every act of discharge*, and cannot generate electrical discharge until it has found a circuit uniting it to the other.

CORRESPONDENCE.

THE FLAME ELECTRIC TEST AND THE VOSS MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I am gratified by Mr. Sprague having made known through your columns the result of his having tested my discovery that an insulated flame indicates the direction of a current of electricity when it is passing through air. He writes, page 222 of your present volume:—"I took the opportunity of testing the action on flame, as to which Mr. Johnstone wrote so strongly some time since, with results, as I expected, very different from his." Now, from what follows of Mr. Sprague's own statement of his results, it is manifest that they are identically the same as mine, as long as Mr. Sprague followed the line of experimenting which I published in your columns, but his remarks also show that when he proceeded to a new line of experimenting of his own then he got different results.

1st. He writes that "he used a benzoline sponge lamp, made of metal, and stood between the balls (of the Voss machine)." Mr. Sprague adds:—"Of course the flame tended towards the — ball, as though blown over from the + (ball), while the lamp was insulated." Now this is an admission that he found the truth of my discovery of 1839, that an insulated flame indicates the direction in which a current of electricity is passing through air.

2nd. Mr. Sprague then proceeds to institute a new set of experiments. After having deprived the lamp of its insulation, he writes:—"But, if a connection was made to it (the metal lamp) from either pole, the flame was attracted to the other pole, provided the machine were worked gently." There is no wonder that Mr. Sprague got these results, and that they are different from my results, because he worked with a flame which was not insulated, and was supported by a metallic stem. But there is something more than this to be taken into account. Mr. Sprague admits that he is acquainted with that which I long ago found to be a very serious defect in the Voss machine, namely, as he writes, "a tendency to self-reversal," that is to say, when experimenting with a Voss machine, and the current of electricity is passing from the right-hand ball to the left-hand ball, in a moment, with the swiftness of a flash of lightning, the machine, by its own spontaneous action, changes the direction of the current of electricity, so that it goes from the left-hand ball to the right-hand ball. When charging a Leyden jar at a Voss machine, sometimes the action is as follows:—Having placed the ball of the Leyden jar near the ball of the Voss machine, which, for the time being, was giving out the current of electricity, the jar would begin to be charged with electricity, but all of a sudden, without any warning, the direction of the current in the machine would be changed, and, to the experimenter's

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surprise, he would find that instead of electricity going into the jar, it was being sucked out* of it.

From these facts it is manifest that the Voss machine cannot be trusted to make with it delicate experiments such as Mr. Sprague has been performing with an uninsulated flame on a metallic stem.—Yours, &c.,

JAMES JOHNSTONE.

Experiment Rooms, 1, James-square, Edinburgh.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I deem it unnecessary to say more on this subject beyond pointing out that Mr. Smillie in his first letter distinctly and repeatedly attributed microphonic action to compression of the carbon; and in his second (having in the interim read Mr. Rathbone's reply and mine) he omits all mention of compression, and talks in a vague way of contacts open (*sic*) and intermittent. I say vague way, because, with the best of intentions, and considerable practical knowledge of the subject to guide me, I have failed utterly to make out what he means. It suffices, however, that he abandons the compression theory. That is what I objected to. If Mr. Smillie writes again, his letter, I think, should take the form of an apology to Professor Blyth. I see that Mr. Smillie in his second letter makes out that I alleged that a brass button would speak as well as a carbon one. Of course I said nothing of the kind. I suggested an experiment with a metallic button—which would, of course, be practically incompressible—for the purpose of showing that microphonic action is due to the contacts between the surfaces, and not to actual compression of the buttons. Mr. Smillie made a brass button speak, which proves my case to the hilt. He says that he did not get the galvanometric action I predicted. If not, his instrument must be a poor one. With a reflecting galvanometer, the spot would have gone off the scale in response to the tickling. Mr. Smillie asks me to give my name. I decline to do so, not being in need of a cheap advertisement.—Yours, &c.,

London, January 22, 1883. LOOSE CONTACT.

RESISTANCE OF ALLOYS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In his inaugural address as President of the Society of Telegraph Engineers and of Electricians, on the 18th inst., Mr. Willoughby Smith drew attention to the fact that the resistance of a wire composed of an alloy of, say, two metals was always higher than the combined resistance of the metals when separate.

This, I believe, is only true in cases of real *chemical* combination, Professor Matthiesen having long ago shown that whenever the combination was simply a *mechanical* mixture the resistance was the same. No explanation of these different behaviours of chemical and mechanical alloys, or mixtures, has ever, so far as I know, been offered, and it is with some diffidence that I now venture to give expression to views which I have long held on the subject.

Suppose a magnetic needle surrounded by a coil composed of two (different) metallic wires twisted together—a mechanical mixture. An electric current, in flowing round this coil, does work (magnetic work) in deflecting the needle, and this deflection we take as a measure of the conductivity, and, therefore, of the resistance of the wire. In the case, however, of the same wires chemically mixed, we have a compound body—a metallic electrolyte, in fact—in flowing through which the electric current does other work besides deflecting the needle. It reduces, or tries to reduce, the alloy into its constituent parts. By the amount of force so expended the magnetic effect of the current is reduced, the conductivity appears to be less, or, in other words, the resistance appears to be greater. But where is the evidence of the chemical work of decomposition here mentioned? May it not be found in the fact that wires which have long conveyed electric currents become brittle, disintegrate? This has been observed in the earlier cables, for instance in the Calais-Dover cable of 1851, and in the wires of old relays, as in the Persian Gulf.

I will ask you to publish this letter in the hope that it may elicit the views of some of your readers on a most interesting subject, as well as one of great practical importance to the electrician, I mean the electrical permanency of metals.

If my views be correct a chemically pure wire will never become brittle, a point which the powerful currents now used in electric lighting will soon enable us to determine.—Yours, &c., J. J. FAHIE.

* I have used the words "sucked out" because I maintain that the experiments I previously published in your columns prove that electricity is a peculiar kind of matter.

AUSTRALIAN TELEGRAPH ALPHABET.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will any one inform me what telegraph alphabet is used on the Government wires in New South Wales? I believe it is not the same as our English alphabet as at present in use in the Post Office, and I should be very much obliged if any of your correspondents can supply me with a a copy of it. H. M.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are alternative solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. RIMINGTON, ESQ. (School of Electrical Engineering), 12, Princes-street, Regent-street.

9. Describe the construction and action of various forms of speed counters for use with dynamos.

Ans. Speed counters may be divided into two classes, viz., those which require to be kept on the dynamo for an accurately-timed minute or half minute, and those which give the speed by simple observation. Of the former class, Harding's patent speed-meter may be taken as an example. It consists of four discs, each divided on the edge into 10 parts, numbered from 0 to 9, so arranged that when the axle, which is attached to the dynamo, makes one revolution it moved the unit wheel $\frac{1}{10}$ of a revolution, and when the unit wheel makes one revolution it moves the tens wheel $\frac{1}{10}$ of a revolution, and so on.

Of the second class, Young's patent speed indicator may be taken as an example, a description of which will be found in No. 15 of the last volume of *The Electrician*. The indications are, in this case, effected by means of a small high-speed centrifugal governor, which acts on an index or pointer.

10. You are required to ascertain the efficiency of a dynamo. Describe in detail the experiments you would carry out for this purpose.

Ans. The efficiency of a dynamo is expressed by the ratio of useful work, or electrical work done in the external circuit to total work or work done upon the machine. To obtain the efficiency of an ordinary dynamo machine, run it through the external resistance for which it was designed, taking the current and E.M.F. at the terminals of the machine, also take the work put into the dynamo by means of a dynamometer such as the transmission power dynamometer.

The total E.M.F. of the machine is obtained by multiplying the E.M.F. at the terminals by the total resistance in circuit, and dividing the result by the external resistance. The power expended in the external circuit $= \frac{E_1 C}{746}$ h.-p. where E_1 = E.M.F. at the terminals of the machine. The total electrical power expended $= \frac{E C}{746}$ h.-p. where E = total E.M.F.

Therefore, the power expended in the coils of the dynamo $= \frac{(E - E_1) C}{546}$ h.-p.

If P be the number of h.-p. registered by the dynamometer, $\frac{E_1 C}{746 P}$ is the efficiency of the dynamo.

$P - \frac{E C}{746}$ being the h.-p. required to overcome the frictin of

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the bearings and the friction and resistance of the air to the revolving armature.

If we do not consider the mechanical waste of power in heating the bearings, &c., the electrical efficiency

$$= \frac{E_1 C}{E C} = \frac{E_1}{E}$$

If R = the total resistance in circuit and r = the external resistance

$$E_1 = r C \quad E = R C,$$

therefore the electrical efficiency $= \frac{r}{R}$.

The electrical efficiency of the shunt dynamo, leaving out of consideration the mechanical waste of power, is rather more complicated than the above.

Let a = resistance of the armature in ohms.
" b = " " field magnets in ohms.
" c = " " external circuit in ohms.
" A = current through armature in amperes.
" B = " " field magnets in amperes.
" C = " " external circuit in amperes.
" e = *er* E.M.F. at the terminals of the machine in volts.

Then

$$e = B b = C c,$$

$$\therefore B = \frac{C c}{b},$$

$$A = B + C.$$

Now work in external circuit $= c C^2$, and total electrical work done equals the product of the total resistance and the square of the total current

$$= A^2 \left(a + \frac{b c}{b + c} \right)$$

$$\text{efficiency} = \frac{c C^2}{A^2 \left(a + \frac{b c}{b + c} \right)}$$

$$\text{but } A^2 = (B + C)^2 \text{ and } B = \frac{c C}{b}$$

$$\therefore \text{efficiency} = \frac{c C^2}{\left(\frac{c C}{b} + C \right)^2 \left\{ \frac{a (b + c) + b c}{b + c} \right\}}$$

$$= \frac{c}{\frac{(b + c)^2}{b^2} \left\{ \frac{a (b + c) + b c}{(b + c)} \right\}}$$

$$= \frac{b^2 c}{a (b + c)^2 + b^2 c + b c^2}.$$

In actual practice we should, as in the case of an ordinary dynamo, have the efficiency $= \frac{e C}{746 P}$ where P is the number of h.-p. indicated in the dynamometer attached to the machine.

CHELSEA ELECTRIC LIGHTING.

The Electric Lighting Committee of the Chelsea Vestry has adopted the following observations upon the Draft Provisional Orders in the Board of Trade, 1883:—"In accordance with the request of the Electric Lighting Committee, we have given full consideration to the provisions contained in the Draft Provisional Order of the Metropolitan (Brush) Electric Light and Power Company (Limited), who are seeking power to supply electricity to Chelsea. In the first instance we think it right to state that we do not regard with favour the scheme as it now stands, because it is prepared upon an unsound basis, many of the clauses in the draft being objectionable and otherwise unfair to consumers. The chief objection to the scheme, however, is that the company are asking for powers to create a 'permissive monopoly' in a manner contrary to the spirit of 'The Electric Lighting Act,' and altogether in our opinion not for the public benefit. Although the company have scheduled the entire parish as the 'proposed area of supply,' they only seek to expend capital to the amount of £14,040. Such a sum would be ridiculously inadequate for so extensive an area. The provisions with regard to:—(*a*) conditions of supply; (*b*) affording relief from compulsion to lay mains in such streets as the company may think fit; (*c*) omitting such streets from the area of supply (but not otherwise relinquishing the company's right over the same); (*d*) the various delays which would occur before the company could be declared to have made default; (*e*) the relief of the company from penalties for neglect and failure to supply; (*f*) the mode of procedure in respect to laying electric mains; (*g*) the breaking up of streets; (*h*) the sub-division of the area of supply; (*i*) the power to make the supply intermittent; (*j*) the cost of service lines under the streets; (*k*) the price and mode of measurement; (*l*) the penalties for default; (*m*) partial revocation of the order; (*n*) the transfer of the undertaking, and (*o*) the duration of the order, are such as in our opinion would render it desirable in the interests of the ratepayers to entirely reject the scheme rather than to submit to the onerous conditions which the company seek to impose. It certainly appears prejudicial to the ratepayers that such a 'permissive' right should be granted for so insignificant an expenditure as £14,040, especially as the provisions for the sale and transfer of the undertaking are so framed that a speculating company might thus cheaply acquire a right to the entire district, and, as electric lighting advances, resell such right (or from time to time any portion thereof) to other persons, a procedure which should be guarded against by strenuous opposition. Under the proposed system of relief from compulsory supply the inhabitants of the more unimportant streets may for ever be prevented from obtaining the benefits of electricity, it being obvious that if the Company were to supply the principal streets only, it would not answer the purpose of another company to take the smaller streets alone, by reason of their isolation, irregularity of consumption, and the cost of supply. With a view to facilitate the introduction of electricity into Chelsea upon a satisfactory basis, at as early a date as possible, and in preference to offering the existing scheme an uncompromising opposition, an amended scheme has been propounded by your surveyor, and his plan forms the foundation of the necessary amendments which the Board of Trade should be asked to include in the draft order. The amended scheme proposes that the Company should forthwith select one of the three areas (or a modification thereof) suggested by your surveyor upon the map herewith submitted; that the obligation to supply the area so prescribed be compulsory, but progressive in the manner specified in the schedules; that the draft order be amended accordingly (the list of streets referred to in the schedules being next filled in as may be agreed upon); and that the remainder of the amendments in the draft, which have been made in red ink, together with the additional clauses, be likewise insisted upon as far as possible. We have conferred with your solicitors (Messrs. Lee and Pembertons), who have, under our instructions, prepared the annexed draft letter to the Board of Trade, together with numerous red ink amendments in the draft order, which we recommend be sent to the Board of Trade, and to Messrs. Walter Webb and Co., the solicitors to the undertakers, not later than the 1st day of February next. The draft orders of the Swan United Electric Light Company, which affect this parish, have also received our attention, and draft letters (prepared by the solicitors) are herewith submitted, which we recommend be sent to the Board of Trade and to the undertakers' solicitors. We also submit a letter from the Board of Trade respecting the capital proposed to be expended.

"CHARLES MOSSOP, Chairman of the Electric Lighting Committee.

"GEO. H. STAYTON, Surveyor to the Vestry."

The suggested letter to be addressed to the Secretary of the Board of Trade states that the capital to be expended, viz, £14,040, is inadequate for the area covered by draft provisional order, and the area should be restricted. It criticises the proposed conditions of supply, and suggests other conditions. Paragraphs also refer, among other things, to the position of mains and stations, to the breaking up of streets, to the intermittent supply, to the cost of service lines, to the price to be charged, to measurement, penalties, removal of mains, provisions for safety, and so on. The most interesting paragraphs are as under:—

"AS TO CONDITIONS OF SUPPLY.—(*a*). For private purposes: The vestry propose that within two years the undertakers shall lay distributing mains and supply electricity along the principal streets of the area chosen, as specified in Shedule A to the order; that they shall in the next year similarly take in hand the streets specified in Schedule B, and that, with regard to the remaining streets, to be described in Schedule C, they shall only be bound to furnish a supply after three years if required by one-third of the occupiers in any street, and within one year after requirement. (*b*). For public purposes: The vestry propose that the undertakers shall not be bound to supply electricity for public purposes unless the vestry shall require them so to do; but that if required the undertakers shall within two years supply the streets specified in Schedule A; within another year the streets specified in Schedule B; and, at any subsequent period, the streets described in Schedule C within six months after requirement.

"AS TO POSITION OF MAINS AND STATIONS.—(*a*.) That before commencing the works the undertakers should submit descriptive plans for their approval, and that, in case of difference, such plans should be settled by the Board of Trade. (*b*.) That, wherever practicable, a distributing main should be laid under the footway on each side of the street, so as to avoid the interruption of traffic and breaking up of roads which would be occasioned if the lines were laid under the roadway. (*c*.) That the

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sites of the electric stations should be approved by them, the undertakers having a right of appeal, in case of difference, to the Board of Trade.

"As to Intermittent Supply.—The vestry object to permission being granted to the undertakers to cease the supply of electricity altogether for two hours per diem. They submit that the undertakers must accept the responsibility of providing a constant supply, as the inconvenience occasioned to consumers may otherwise be very great.

"As to Price.—The draft order contains only general provisions in regard to the price to be charged by the undertakers. The vestry submit that a maximum price should be fixed by the Board of Trade for the supply of electricity both for public and private purposes; and that, as electricity is at present experimental, the prices charged should be revised by the Board of Trade every five years. The vestry also submit that they should be heard on such revisions, and be empowered to appoint some qualified person to examine the company's accounts."

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

PRESIDENTIAL ADDRESS.

At the meeting of this society, on Thursday, the 18th inst., the newly-elected president, Mr. Willoughby Smith, was installed by the retiring president, Colonel C. E. Webber, R.E. A hearty vote of thanks to the latter, and a message of condolence to the family of the late ex-president, Mr. C. V. Walker, F.R.S., on the loss they had sustained by his death, having been agreed to, Mr. Willoughby Smith then read his inaugural address. After referring to the youth of the society and the great progress it had made during the short period of its existence—a circumstance which was to be ascribed not to any long line of illustrious names which some ancient societies could boast of, but to the rapid growth of electrical science, and extension of its application to practical affairs which had taken place during the past ten or eleven years—Mr. Smith went on to show that every branch of science has progressed in proportion to the accuracy and delicacy of the appliances with which they have to work. And this was true of no branch of science more than of that in which telegraph engineers and electricians were interested. Besides apparatus, however, there was also needed an exact system of measurements upon which uniform and coherent calculations could be made. Some advances had been made in these latter respects by the adoption of electrical units; but a good deal still remained to be done, and it was to be hoped that the Paris Electrical Congress, which had adjourned till the end of the present year, would by that time be in a position to unanimously agree upon standards which would be at once practical, international, and reliable. To the practical electrician—and Mr. Smith confined himself throughout to practical matters—the material was the important thing, not the definition or the nomenclature. For example, it was possible to buy copper wire of higher standard than the one authoritatively recognised, the characteristics of so-called pure copper wire differing greatly with the place of its manufacture. This was shown by the results of tests of five samples of pure copper of same length, gauge, and temperature, which showed that their specific conductivity was a long way from being uniform. Mr. Smith then dealt with the subject of dielectrics with which he had had a great deal to do in connection with submarine cables. Here, again, the change or original difference of material rendered mere definition of hardly any use. Difference in age and temperature completely alters the characteristics of the insulator. Resistance of the gutta percha, for example, increases with age, as shown by a table of tests taken over a succession of years, the increase in some instances being nearly threefold. Again, it was more and more evident that a constant electromotive force should be at our disposal for electrical measurements. Much, no doubt, had been done in this direction, but it was still a fact that no battery had yet been devised whose constancy could be maintained and depended upon for any length of time.

Amongst the many discoveries that had remained idle and unserviceable for years, Mr. Smith supposed he must include that of the peculiar properties of selenium with which his own name was associated. At one moment expectations had been raised as to its utility in connection with the photophone; but he had been sceptical about this from the first, and events had shown that the effects were not due to the use of selenium, but were common to other substances, and attributable to radiant heat rather than to light. Nevertheless, he was sure that some work was to be got out of this metal, for where light was absorbed, as was the case with selenium, work was capable of being performed by it. In connection with this matter some experiments he had made with various kinds of light, from an ordinary candle to that of an electric light, were of interest. A selenium cell being placed in circuit with a galvanometer, it was found that the rise and fall consequent upon the change of light, although very marked, were not completed all at once, the rise being followed by a slowly succeeding and further deflection, the fall by a gradual further decline. This showed that the absorption and giving out were not instantaneous, but occupied an appreciable time.

Turning to the subject of earth currents and similar phenomena, Mr. Smith observed that so soon as "earth" was used for the return current, as it was then called, on telegraph lines, magnetic disturbances were observed, and gave much trouble. To the present day we had not by any means eliminated this disturbing element. But some useful results might follow therefrom if it induced us to establish points of observation, as had been done in respect to terrestrial magnetism; to take note of and collect statistics as to earth currents, their strength, their direction and duration. If we could, so to speak, link the aurora to terrestrial magnetism, and this again to earth currents, how much more easily might we then be able to link together many other natural phenomena in one and the same chain!

After sketching the adaptation of the magnet to various electrical uses Mr. Smith pointed out that we were now engaged in obtaining powerful magnetic fields, especially for electric lighting purposes, but that we had not yet arrived at certainty as to the quality of the iron to be employed or the best way of applying the wire. Illustrating this latter point diagrammatically, the best position could be shown by sliding a secondary coil, to which a galvanometer was connected, along a primary coil in the form of a bar electro-magnet. The deflections would thus be shown to be greatest when the lines of force cut the secondary coil at right angles. As regards the metal employed, his experiments, which had already been published, were here illustrated. Two flat spirals facing each other some distance apart, and connected with reversers, were separated by the metal plate to be tried. The results were very curious, and depended not entirely upon the character of the metal, but upon the speed of the reversals. Copper was unable to intercept the inductive effects between the two spirals when the reversals were slow; whilst iron was uniform, or almost uniform, irrespective of speed. The same was true of lead; but zinc and tin varied the induction with every variation in the speed of reversals.

Some defects in our present system of protecting buildings from the effects of lightning were dealt with next, and the hope expressed that, as the use of electric light and power became general, the care of lightning conductors would fall into the hands of more competent men. With regard to electric lighting, the chief defects noticeable at present were the frailty and impurity of carbons, and the insecurity of insulation. As to the former, their manufacture goes on steadily improving, and, in regard to the latter, experience was teaching its useful lessons every day. Metals, it was suspected, fuse most easily when a current is passing through them, and, as the temperature alters the resistance, the insulator is subject to an increasing liability to destruction the longer the current remains on. The unprecedented demand upon the resources of electrical engineering had for a time caused inexperience to step in where experience feared to tread; but this danger is now rapidly disappearing. One other drawback felt at present is the want of a good system of photometric measurements, the eye not being trustworthy for so delicate an operation.

The storage of electricity was, of course, a great *desideratum*, and, backed by the name of one who stood very high in the profession, a secondary battery of extraordinary pretensions had raised expectation to the highest. But two years have passed away without any useful result following the importation from Paris of that marvellous box, and in the interval experiments had not proved favourable to this class of battery. The difficulties of storage, though probably not insurmountable, have yet to be overcome. When submarine cables were first projected all sorts of imaginary difficulties and dangers were conjured up against them, but they have triumphed over all obstacles, and he, Mr. Smith, believed that in like manner electric lighting enterprise will achieve a great success. After some brief references to the Postal Telegraphs, the telephone, and the microphone, Mr. Smith concluded with an earnest appeal to students of electricity, both theoretical and applied, not to be in a hurry to make a market of their talents, never to be ashamed to confess ignorance, always ready to listen to those who can teach; and, as to the rest, learn above all things to "labour and to wait" for that reward which, sooner or later, comes to every honest and patient worker.

A vote of thanks, and a request that the address be printed in the society's *Journal*, having been proposed by Professor Adams, and seconded by Mr. Spagnoletti, it was carried unanimously.

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THEORY AND PRACTICE.

The extremely interesting and eminently practical address delivered before the Society of Telegraph Engineers and of Electricians last week by its newly elected president may be said to be a sort of supplement to another presidential address delivered last August. Comparison is unavoidable; and although comparisons are things to be generally avoided, in this case happily they can be instituted without being odious to anybody. Indeed, the two addresses to which we are referring may be taken, as a whole, with much profit, and as mutually balancing each other. We pointed out at the time some of the defects of Dr. Siemens's scheme of scientific development, and we think that those defects are, to a great extent, now made up by that of Mr. Willoughby Smith.

Differing as do these two representative men on the debatable ground of ways and means, they resemble each other apparently in their zeal for the practical side of scientific investigation. Possibly as individuals their training and career may have been very unlike; but they are both practical electricians who in part adopt and apply the scientific researches of others to practical purposes, and in part depend upon their own independent study. Yet no one who heard their careful and deliberate utterances in regard to these matters could fail to notice that their respective standpoints were not exactly the same. Both were anxious that practice should go hand-in-hand with theory, and that neither should disdain the companionship. But it was plain Dr. Siemens thought that science should take the lead, whilst it is equally plain that Mr. Willoughby Smith troubles himself not the least about who should lead, but is content to affirm that practice does lead. Of course, the lead in this connection means the lead in practical application, and, no doubt, the statement in that sense is correct. Dr. Siemens wished to readjust matters by holding out a strong inducement on the one hand to the scientist to become more practical, and on the other to the practitioner to become more scientific. We ventured to suggest that if the scientist entered on a career of the kind recommended, a career repugnant to all the oldest and most cherished traditions of the scientific school, he would run the risk not only of losing caste but of wasting time. We were not alone in taking this view, and on the whole it may be predicted as certain that, except under the temporary temptation of a money-making mania, the scientist will follow on the old lines in spite of all invitations to depart from them.

The appeal of the new president of the Society of Telegraph Engineers and of Electricians—what a pity this society itself does not take practical advice and shorten its title!—is of quite another complexion. Dr. Siemens had proffered his encouragement and advice to the scientist, and had reserved all his scoldings for the working practitioner. Mr. Smith almost reverses the operation, giving, at all events, the scientist to understand that he does not quite come up to Mr. Smith's ideal—certainly not up to his requirements. His paper, in fact, was the statement of a long list of deficiencies which science had not yet been able to supply, and for which the working practitioner was still waiting. If the scientific school took it into its head to get rich in haste, there would be little speed made in satisfying the wants of practical men. What these wants were Mr. Smith indicated categorically, and with an unmistakable moral. There remains still a great deal that science has yet to discover, to explain, and to render accessible to practical minds; and, in short, if science would stick to its own business as exclusively as it used to do, we might get on, perhaps, a little faster. Practical minds, on the other hand, could not afford the time, nor do they possess the special aptitudes for dipping deep into the stream of pure science. They are content to work on, and respectfully await what the scientific intellect is pleased to bestow; but, at the same time, reserving their right to grumble if what they get is not quite up to their expectations. They had, above all things, a special right to complain, and even to protest, against the theoretical scientist losing his head, and swelling the cry of the ignorant multitude. On more than one occasion in recent years practical men have had to stand aside, and look on with bewildered incredulity at projects which their practical instinct convinced them were doomed to disappointment, but against which they dare not raise a whisper—for they were only "mere practitioners." Mr. Smith did not exactly say all this; but we can easily imagine he meant it.

Quite in keeping with all this was his advice to students of all classes—advice which, as Professor Adams remarked, was

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as applicable to the old as to the young. Matthew Arnold, when lecturing on lucidity, told us not to think but to be patient. All things come to him who knows how to wait, is his favourite proverb. Mr. Smith, too, has his favourite maxim. It is a very ancient one, and it comes from the East, where wisdom was invented but never patented, namely,—Be quick to learn, my child, how to say *I do not know*. What agonies mankind would have been spared if that simple lesson in modesty and sincerity had been universally learnt! It is a compendium of all the virtues in the business of this life to them who have sense to apply it. But to them who have not, its merits seem vague, visionary, and unproductive, therefore we will not descant upon them. Suffice it to say that in Mr. Willoughby Smith's estimation minding your own business, closing your mouth generally, and opening your ears always, is the way to become wise; and, with due perseverance and patience in that course, your reward is certain—practical advice with which we cordially agree, and which appropriately concluded a very practical address.

LITERATURE.

The Electric Lighting Act, 1882, *the Acts Incorporated therewith, the Board of Trade Rules, together with Notes and Cases.* By C. Higgins, M.A., and E. W. W. Edwards. London: W. Clowes and Sons.

If the electric light ever becomes as common an illuminant as gas, it will be necessary for many of those interested in it to know something of the various Acts of Parliament and rules of the Board of Trade, &c., under which the light will frequently have to be supplied. The work before us annotates and explains the recent Act, as well as gives information upon various technical matters, the latter being chiefly compiled from the evidence of those examined before the Select Committee. The copious references to cases will be found of great value, as it is by these decisions one learns exactly what can be done and what cannot be done under this and other Acts of Parliament. In appendices are given the "Board of Trade Arbitrations, &c., Act, 1874," "Telegraph Act, 1878," and the "Rules of the Board of Trade with respect to Applications for Licenses and Provisional Orders." Altogether the work will commend itself to those who desire information. It is, in addition, well printed—a valuable feature, but one which in these days is not always thought of much account.

Useful Rules and Tables. By Professor W. J. M. Rankine. Sixth Edition. Revised by W. J. Millar, C.E. With an Appendix by A. Jamieson, C.E. London: C. Griffin and Co.

Professor Rankine's literary works were of a type and character which marked a new era in books pertaining to engineering, hence they stand their ground against the many meretricious books that have since been written. There is no royal road, and the engineer who wants the subject brought down to his comprehension is incomparably inferior to the engineer who determines to raise the level of his comprehension so that he can really understand the laws under which his work is to be tested. No doubt a good deal can and has been done by mere rule of thumb, but even this and acquired experience will be fatal to success if trusted too much. Professor Rankine never wrote for those who professed themselves ignorant of the fundamental rules of mathematics. The work before us, however, can hardly be called a literary production, it is more a compilation of rules of formulæ by a competent hand. That it is found useful is proved by this being the sixth edition. Mr. Millar is a competent editor, and we have no doubt was wise in adding an appendix of electrical formula to the book. This appendix by Mr. Jamieson fills sixty-two pages, and is an *olla podrida* of rules, formulæ, descriptions, &c., compiled from a variety of sources, showing the compiler's wide reading. The book will be found exceptionally useful for reference, and its contents may be taken to be trustworthy, after having been subjected to such long use and careful supervision.

Les Téléphones Usuels. Transmetteurs et Récepteurs Bell, Edison, Hughes, Ader, Blake, Crossley, Gower, &c. Par Charles Mourlon. Brussels: A. N. Lebèque et Cie.

Some of the elders among us can remember when the science of chemistry was discussed within the covers of an ordinary sized volume. We have seen something of its wonderful development, and watched how its votaries more and more gave up the study of the subject as a whole in favour of special branches, each of which contained material for the work of a lifetime. Electrical science is fast following in the footsteps of the sister science, and splitting up into branches. We shall soon have specialists in telegraphy, telephony, electro-chemistry, and so on; indeed, our bookshelves are beginning to show signs of these special studies in *brochures* devoted to one or other branch of the subject. The one before us is a simple work, describing the various articulating telephones, or, rather, the various apparatus connected with articulating telephony. Telephonic apparatus is, by the author, said to be of two kinds, "Les Téléphones Musicaux" and "Les Téléphones d'Articulation," the latter only being dealt with in the book. A number of illustrations are given besides those of the instruments themselves, showing the methods of connecting, insulators, &c., central station, switching apparatus, and so on. The book partakes somewhat of the nature of a firm's price list, the author being the manager of Mourlon and Company's factories, and the work giving lists of prices for installations of various kinds. These lists, however, occupy only some four pages out of a hundred. A list of publications on telephony is given at the end of the book.

Electric Telegraphy. By Professor Dr. E. Zetsche. Leipsic: J. J. Webber, 1883.

This is an elementary handbook by one of the ablest and most painstaking of German writers. The first part of the book refers to the apparatus used, describing ordinary batteries, thermo-batteries, and the dynamo, besides treating of the instruments and laws by which measurements are made. We next come to telegraphy proper, and find the early experiments of Gauss and Weber, of Steinheit, of Cooke and Wheatstone, &c., described and illustrated, gradually coming to the descriptions of the more modern instruments, such as various sounders, writing apparatus, &c. Cable work, duplex and multiplex working, &c., are all discussed. There is nothing much that is new in the book, but for four marks—practically four shillings—we get in German a far better illustrated and more compendious handbook than can be obtained in England at a similar cost. At the end of his book Dr. Zetsche gives a statistical table relating to telegraphy in 1881. It will be interesting in the future to note the effect which the development of telephony will have upon telegraphy, and especially upon local telegraphy. To those who find a pleasure in reading the German character—not German in Roman type—we commend this book.

The Telephone Case.—The case of the United Telephone Company *v.* Harrison Cox-Walker and Co. came on before the Master of the Rolls and Lords Justices Lindley and Bowen on Tuesday last. It will be remembered that the plaintiffs obtained, in April last, an injunction against the defendants for infringing the Bell telephone patent. This was an appeal against the above judgment by the defendants. The case was not concluded when we went to press, and was to be heard again on Friday. We shall, therefore, defer our report until next week.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XIII.

In the practical execution of the joint test three observations have to be made for the cable—that is to say, three readings are taken. These readings are not to determine any numerical value for the deflections, but they must not be larger than a certain relative amount, and their direction on the scale must be determinate. The first of these is the *inductive charge*, the second shows the *amount of leakage*, and the third is the *inductive discharge*.

The inductive charge (also called the immediate charge) is explained by saying that when the battery key is depressed, and a charge thus sent into the joint, a corresponding charge is induced in the water in the trough; and if we immediately connect the galvanometer to the latter by putting down C (see Figs.), this induced charge is observed by the deflection which it causes—it may be towards the right hand, the spot being arranged in the centre of the scale. The second operation is really a repetition of the first, the difference being that the battery key is kept down for some minutes before the galvanometer key is depressed, and, in addition, the condenser key D is kept down at the same time. This has already been referred to as the accumulation and measurement of the leakage from the joint. The deflection will be smaller than that from the induction charge, but in the same direction on the scale. It has been suggested that the deflection from the induced charge is really caused by leakage, and is not inductive but direct; but the fact now stated that the deflection is larger than that from the accumulated charge seems to disprove the idea, although it is at first sight favoured by the direction on the scale being the same in both cases. The third observation, that of the inductive discharge, is effected by releasing the condenser key D and instantly depressing C, and then releasing B, touching down A, when a deflection is seen on the scale in the opposite direction to that of the two first, but of the same value as that given by the inductive charge; that is, the spot travels over the same number of divisions in each of these two cases. The cable is thus put to earth, and the charge removed. It is said to rush out of the cable, and thereby causes an inductive charge in the opposite direction to that resulting from the first operation, and so it is styled an inductive discharge. These inductive charges are interesting features in the joint test, and have been the subject of discussion involving opposite opinions on the part of some who have advanced different theories as to their real interpretation. We cannot stop to consider these just now, but must proceed with the practical duties preceding and attending the operation, which are as follow. It is usual to keep a book specially for the record of joint tests. It is ruled in columns containing the joint numbers, which run consecutively, the numbers of the several coils which each joint unites, the machines to which they belong and other particulars. When a fresh coil of core is to be joined to the former length passing through any machine an order is given out to the jointer detailing the coil numbers, &c., and accompanied by a leather label bearing the number of the joint stamped on it. At the same time the entry is made in the joint book of the particulars contained in the order. When the joint is finished the jointer returns this order with the hour and minute of completion recorded on it. Six hours are generally allowed between the time of finishing and that of testing; that is, the joint should soak in water for six hours before allowing it to be tested. Thus, if a joint were finished at two it should not be tested before eight o'clock, and this latter hour is entered in the book as the proper time for the operation. The electrician on duty will examine the joint book from time to time, and order the connections outside to be made for the proper hour. The learner will understand that while a joint is being made in a length which is being sheathed on a machine that particular section of cable cannot be tested. When the jointer is ready to begin he requests the operators in the testing room to disconnect that machine. Referring to our explanation of the large commutator in Nos. I. and V. of this series, it will be seen what this means. In this particular instance there is no actual disconnection within the room beyond separating from the electrometer (No. V.). It is only necessary to be sure that the plug connecting the horizontal with the upright or cable (or core) bar is not inserted, so that there can be, for example, no battery current passing in the section. But the core lead which is joined to the back of the commutator outside the testing room must be disconnected from the end of the core, part of which is passing through the machine, because the joint is to be made between this end and one end of the fresh length or drum of core, and the other end of this latter will in its turn be connected to the lead just removed from the nearly used-up core still being sheathed.

As regards the jointer's request for disconnection just mentioned, it may be noted that no one is allowed on any account to disconnect any of the leads or sections outside in the cable shop without orders from the electrician. This rule requires very strict enforcement, for it unfortunately happens that if an instance does occur nobody will ever own to having done it.

Of course a sufficient length of core is always left coiled in the core tank to allow the end to be jointed without stopping the machine. It is customary to allow about 40 minutes from the time at which the request for disconnecting the machine was made until the lead at the back of the commutator need be joined to the fresh coil of core. The battery-man often does this sooner without direct instructions; but, generally speaking, as soon as the joint order is returned by the jointer, it is imperative to take a short copper resistance test on the bridge to be sure that the proper coil has been added, for each coil is specially appointed to its place in the cable. Very often two coils are joined on, having been previously jointed together (end to end, of course). In another book recording the composition of each machine section, the numbers, lengths, resistances, &c., of each coil are entered in consecutive order, the total length and copper resistance at any time being apparent at a glance. When, therefore, a fresh coil is added, the *total* resistance is known, and since the last C R (copper resistance) test before joining on is recorded in its appropriate column, a test at this time ought to show that the proper addition has been made. Suppose, for example, that the section gave 120 ohms for C R before the coil was added, and that the fresh coil had 10 ohms' resistance (as known from the previous core test), the section, after the joining on of this coil, ought to show when tested 130 ohms instead of 120. There is generally a difference of from 3 to 5 per cent. between the copper resistance of a given length tested as core, and the same tested as cable; but, if the result in the case before us differed considerably from the amount to be expected under the given conditions, there is something wrong, and the matter must be at once inquired into. This precautionary test should always be taken when a joint has been made in a working section.

We will now suppose that a joint is entered in the joint book for testing at 3 p.m. It will, under ordinary circumstances, have been finished at 9 a.m., and placed in water. The battery-man on duty will probably have made the necessary connections outside the room shortly before three, but, if not, instructions must be given in time. We require one lead connecting with the conductor of the cable, and one for the trough (or the plate in the water), and, further, one end of the section must be free, that is, insulated. In a room where the large commutator is arranged as we have suggested, we should connect with the cable by a plug joining the cable bar by a contact-piece from which a lead may go to the testing table (see Fig. 23); the core end would either be insulated at the core bar, seen in Fig. 9, No. V., in the electrometer test, if the fresh coil had been joined to the core lead, or more probably the end would be free at the core tank, and the battery-man would join the trough to a lead whose other end would be joined to the back of one of the ebonite terminals on the commutator. To this we should join a lead which is connected to a point on the testing table (Fig. 23), and we have thus our arrangements for the test.

A separate set of keys, &c., and a separate galvanometer

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and condenser, particularly the latter, are kept in readiness for this operation. The condenser should, as remarked in the case of other tests, be always short-circuited when not being used. A large one is not necessary for this test, and a form is sometimes employed which is not arranged for joining the poles by a plug. In this event a separate lead should connect each pole with earth, one of these going first to a contact point which can be put to earth by depressing a key piece. This will be illustrated presently.

Where a long cable is being manufactured there may be thirty or forty joints to be tested daily, and there is not much spare time, as the joint is usually "wanted" at or close to the hour fixed on for testing it, and sometimes the six hours' interval, after finishing its manufacture, is unavoidably shortened (though never by more than three hours) if the machine has worked faster than was expected. It is

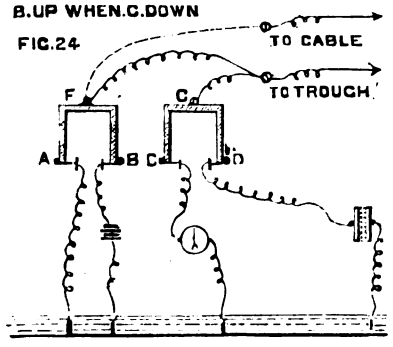

FIG. 24.—For insulation of trough.

"wanted" in the first place that it may be "served," that is, covered with yarn as the whole of the core is before entering the sheathing machine, and secondly, that this operation may be completed in good time to prevent stoppage of the machine. We may here repeat the injunction to avoid most carefully doing anything which may bring about this result. It would be regarded as worse than a blunder, and, therefore, the electrician will do well to look over the connections, and assure himself that everything is in perfect order a few minutes before the time. He should see that all connecting screws are tight, and all leading wires, short or long, are in their right places; that there is nothing wrong with the lamp, and that the adjustments of the galvanometer are in order—that is to say, that the spot is properly reflected and deflects

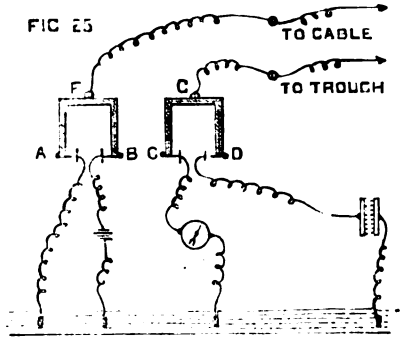

FIG. 25.—For inductive charge.

freely, and that the sensitiveness of the mirror (magnet) is not too great, for it is possible that the large directing magnet of the instrument may have been shifted from its proper position. Generally speaking, the battery-man may be trusted to have arranged his connections outside rightly, so that the operator need not go out to examine them. This necessity may, however, arrive, as we shall see, but, if so, it will become apparent during the course of the test.

A separate battery is usually, though not always, employed for the test. If it be used for others there will probably be a battery commutator for dividing the number of cells, as previously explained in No. VII. (Fig. 13). In this case the plug must be inserted in the proper place for the 200 or 300 cells which are generally used. The first thing to be done is to ascertain the sufficient insulation of the trough, since, if there be any leakage to earth through its surface, or, rather, that of the stand, the conditions of the test would be disturbed. We desire to collect the leakage from the joint in the condenser and observe it by discharging through the galvanometer, and if the trough were not well insulated, this object would be frustrated, and besides this there would be a constant current passing to earth, and the galvanometer indications would be misleading. One way of determining the question would be by removing the battery leading wire from the cable and attaching it to the wire of the trough (see Fig. 24, in which the dotted line shows where the lead is removed). Then depress D and B, and instantly releasing B, touch down C. By this means the trough is charged, the condenser takes up the charge, and it is discharged through the galvanometer, producing a deflection which represents the full charge from the battery. Then repeat the observation (first short-circuiting the condenser

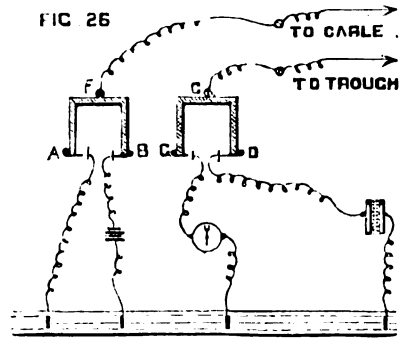

FIG. 26.—For accumulation of charge. C down after three minutes.

for a moment or two), but keep down B (and D) for, say one minute, and discharge as before by touching down C. If the deflection is so much smaller than the first that more than 2 or 3 per cent. loss of charge is the result, the trough is not well insulated, because it allowed too much of the charge to escape to earth. In the illustration of the test with different connections we shall show another way of performing this operation.

Supposing the result to be satisfactory we may proceed. The battery wire will be returned to its former connection, and the condenser briefly short-circuited. Having the spot of light in the centre of the scale at zero, depress C and immediately afterwards B also, keeping an eye on the scale (Fig. 25). If the deflection is of the right amount, a point

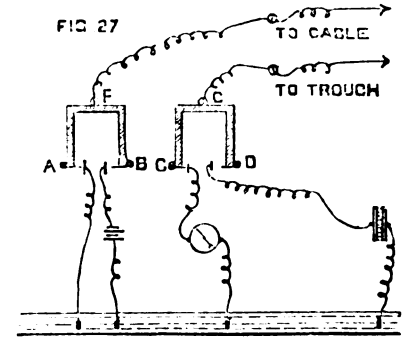

FIG. 27.—For inductive discharge.

depending on prearrangement of the galvanometer and known beforehand, release C and clamp down B and D. The charge is now entering the cable (and joint), and any leakage through the latter is passing to the condenser, and there accumulating (Fig. 26). This may continue for any period chosen, say three minutes. At the end of this time touch down C; this connects the galvanometer to the condenser, and the accumulated charge in the latter is discharged through the former to earth. Supposing the deflection thus caused to be no larger than the amount fixed, it is concluded that the leakage is not too great; at once, therefore, release B and touch down A and C. The joint is hereby discharged to earth, and the *inductive* discharge from this trough causes a deflection on the scale in direction opposite to the two former deflections, and equal in amount to the first (Fig. 27). The joint may now be passed, that is, a label stating the fact

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is sent out to the cable shop. [Note—Fig. 28 illustrates more clearly the connections in the room; the *dotted* lines are *outside* of the room from the back of the commutator.]

This account of the test is appropriate to the arrangement of the connections as given in the figures, and though, as already stated, there are other ways of connecting up for this operation the principle is the same for all. But as these various connections are always confusing to a beginner, and since all testing rooms have not the same modes of arranging the tests, it is necessary to give more than one example. The standard fixed for the amount of deflections to be allowed is not rigidly binding in all cases, but whenever there is any doubt as to the result, if the deflections seem to exceed the proper limit

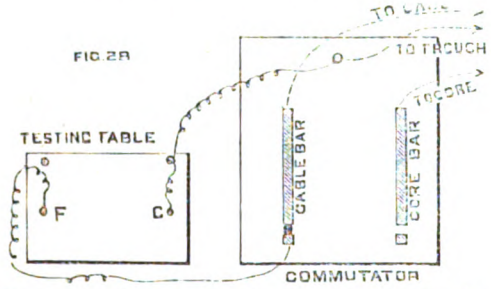

FIG. 28.—Connections for joint test in room. F and G refer to F G in Figs. 23 to 27.

(under the governing conditions), a piece of the core must be put in the trough and tested in the same way, when, if the same deflections are obtained, the joint may be passed. The latter is merely lifted out and wiped dry, and the length pulled along some little way, and the core placed in the water and secured by the hooks. The various contingencies which may cause trouble or irregular results in the test, and which must be taken into consideration in pronouncing on the quality of the joint, will be enumerated presently. We will first give two other plans of connections and take the test with them, and also show how to proceed when using the electrometer instead of the galvanometer and condenser for the same purpose.

CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture II.—The Dynamo in Practice.

(CONTINUED FROM PAGE 238.)

Armatures.

The armatures of dynamos of the first class may be roughly classified in three groups, according to the manner of arranging the coils. These three groups are—

(1.) *Ring armatures*, in which the coils are grouped upon a ring, whose principal axis of symmetry is its axis of rotation also.

(2.) *Drum armatures*, in which the coils are wound longitudinally over the surface of a drum or cylinder.

(3.) *Pole armatures*, having coils wound on separate poles, projecting radially all round the periphery of a disc or central hub.

(To these we shall add a fourth form, namely, that of *Disc armatures*, when we deal with dynamos of the second class.)

The object of all these combinations is to obtain the practical continuity of current spoken of in section *t* of the first lecture. Some of the individual coils should be moving through the position of maximum action, whilst others are passing the neutral point, and are temporarily idle. Hence a symmetrical arrangement around an axis is needed. Ring-armatures are adopted in practice in the dynamos of Pacinotti, Gramme, Schückert, Gülcher, Fein, Heinrichs, De Meritens, Brush, Jürgensen, and others. Drum armatures are found in the Siemens (Alteneck), Edison, Elphinstone-Vincent, Laing, and other machines. Pole-armatures are used in the dynamos of Allen and of Lontin. There are several intermediate forms. The Bürgin armature consists of eight or ten rings, side by side, so as to form a drum. The Lontin (continuous-current dynamo) has the radial poles affixed upon the surface of a cylinder. The Maxim armature is a hollow drum wound like a Gramme ring, and has therefore a great quantity of idle wire on the inner surface of the drum. The Weston armature has the drum surface cut up into longitudinal poles; there is a similar armature by Jablochkoff, in which the poles are oblique.

Ring armatures are found in many machines, but the ingenuity of inventors has been exercised chiefly in three directions:—The securing of practical continuity, the avoidance of Foucault currents in the cores, and the reduction of useless resistance. In the greater part of these machines the coils that form the sections of the ring are connected in series, the end of one to the beginning of the next, so that there is a continuous circuit all round, an attachment being made between each pair to a bar or segment of the collector. Most inventors have been content to secure approximate continuity by making the number of sections numerous. One inventor, Professor Perry, has built up a ring with coils wound obliquely, so that the one coil reaches the neutral point before the preceding one has passed it. I cannot help doubting the advantage of this arrangement; which, moreover, presents mechanical difficulties in construction. Pacinotti's early dynamo had the coils wound between projecting teeth upon an iron ring. Gramme rejected these cogs, preferring that the coils should be wound round the entire surface of the endless core. To prevent wasteful currents in the cores, Gramme employed for that portion a coil of varnished iron wire of many turns. In Gülcher's latest dynamo, the ring core is made up of thin flat rings cut out of sheet iron, furnished with projecting cogs, and laid upon one another. The parts of the coils which pass through the interior of the ring (in spite of the late M. Antoine Breguet's ingenious proof that some of the lines of force of the field bent round and turned back into the core in this interior region) are comparatively idle. They cut very few lines of force as they rotate, and therefore offer a wasteful resistance. Inventors have essayed to reduce this source of loss, by either fitting projecting flanges to the pole pieces (as in Fein's dynamo) or by using internal magnets (as in Jürgensen's dynamo), or else by flattening the ring into a disc form, so as to reduce the interior parts of the ring-coils into an insignificant amount. This is done in the dynamos of Schückert and of Gülcher. In the latest form of Gülcher's dynamo the field magnets, front and back of the ring, are united on the right and left sides in a pair of hollow pole pieces, which form cases over the ring, covering a considerable part of it. The collector is identical with that of Gramme, but very substantial.

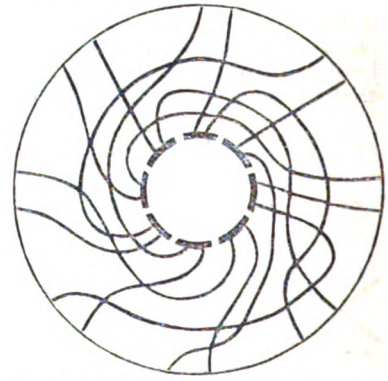

FIG. 22.—Alteneck-Siemens Winding (old).

The drum-armatures may all be regarded as modifications of Siemens's well-known longitudinal shuttle-form armature of 1856, the multiplicity of sections of the coils affording practical continuity in the currents. In some of Siemens's machines the cores are of wood, overspun with iron wire circumferentially, before receiving the longitudinal windings. In another of their machines there is a stationary iron core, outside which the hollow drum revolves; in other machines, again, there is no iron in the armature beyond the driving-spindle. In all of the Siemens armatures the individual coils occupy a diametral position with respect to the cylindrical core, but the mode of connecting up the separate diametral sections is not the same in all. In the older of the Alteneck-Siemens windings the sections were not connected together symmetrically, the connexions (for an eight-part collector) being as in Fig. 22. But in the more recent machines a symmetrical plan has been adhered to, as shown in Fig. 23.

In this system, as in the Gramme ring, the successive sections of coils ranged round the armature are connected together continuously, the end of one section, and the beginning of the next, being both united to one segment or bar of the collector. A symmetrical arrangement is, of course, preferable, not only

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for ease of construction, but because it is important that there should never be any great difference of potential between one segment of the collector and its next neighbour; otherwise there will be increased liability to spark, and form arcs across the intervening gap. In Edison's modification of the drum-armature, the winding, though symmetrical in one sense, is singular, inasmuch as the number of sections is an odd number. In the first machines there were seven paths, as shown in Fig. 24, taken from Edison's patent specification. In his latest giant machines the number of sections is forty-nine. One consequence of this peculiarity of structure is that, if the brushes are set diametrically opposite to one another, they will not pass at the same instant from section to section of the collector; one of them will be short-circuiting one of the sections, whilst the other is at the middle of the opposite collector. The armature of these latest of Edison's dynamos

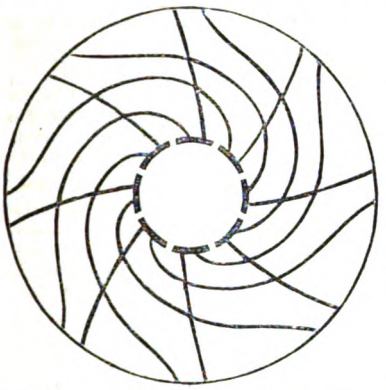

Fig. 23.—Alteneck-Siemens Winding (new).

is not wound up with wire, but, like some of Siemens's electro-plating dynamos, is constructed of solid bars of copper, arranged around the periphery of a drum. The ends are connected across by washers or discs of copper, insulated from each other, and having projecting lugs, to which the copper bars are attached. Such discs present much less resistance than mere strips would do. The connections are in the following order:—Each of the forty-nine bars of the collector is connected to one of the forty-nine discs at the anterior end of the drum, which is connected by a lug-piece on one side, to one of the ninety-eight copper bars. The current generated in this bar runs to the further end of the machine, enters a disc at that end, crosses the disc, and returns along a bar diametrically opposite that along which it started. The anterior end of this bar is attached to a lug-piece of the next disc to that from which we began to trace the connections, it

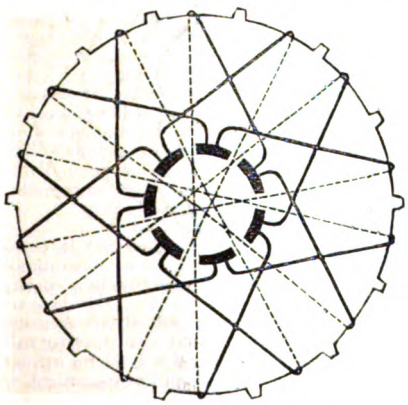

Fig. 24.—Edison's Winding.

crosses this disc to the bar next but one to that first considered, and so round again. The two lug-pieces of the individual discs at the anterior end are, therefore, not exactly opposite each other, diametrically, as the connections advance through $\frac{1}{49}$ of the circumference at each of the 49 paths. It is noticeable in this machine that the collector is very substantially built, and that a screen is fixed between the collector and the rest of the armature, to prevent any copper-dust from flying back or clogging the insulation between the bars or discs. There are no fewer than five pairs of brushes, the tendency to sparking being thereby greatly reduced. The core of the armature is made of very thin discs of iron,* separated, by mica or asbestos paper, from each other, and clamped together. Some exception may be taken to the use of such stout copper bars, as being more likely to heat from local currents than would be the case if bundles of straps, or laminæ of copper were substituted. And, indeed, the presence of a 4-horse power fan to cool the armature, is suggestive that continuous running is liable to heat the armature.

Before passing on from the subject of armatures, it is worth while to mention the peculiarity of form of the Bürgin armature, which has already been spoken of as consisting of eight, or in the newest Bürgin machines, as constructed by Mr. R. E. Crompton, of ten rings, set side by side.* Each ring is made of a hexagonal coil of iron wire, mounted upon light metal spokes, which meet the corners of the hexagon. Over this hexagonal frame, six coils of covered copper wire are wound, being thickest at the six points intermediate between the spokes, thus making up the form of each ring to nearly a circle. Each of the six coils is separated from its neighbour, and each of the ten rings is fixed to the axis $\frac{1}{60}$ of the circumference in advance of its neighbour, so that the sixty separate coils are in fact arranged equidistantly (and symmetrically, as viewed from the end) around the axis. There is a 60-part collector, each bar of which is connected to the end of one coil and to the beginning of the coil that is one-sixtieth in advance; that is, to the corresponding coil of the next ring. This armature has the great practical advantages of being easy in construction, light, and with plenty of ventilation.

In the Elphinstone-Vincent dynamo there is a drum-armature of a somewhat distinct order, the separate coils being made of a rectangular form, and then laid upon the sides of a hollow papier-maché drum in an overlapping manner, and curved to fit it. The field is a complex one, with six external and six internal poles, and is very intense, owing to the proximity of these poles. The parallelogram-shaped coils are connected together so as to work as three machines, and feed three pairs of brushes; which may again be united, either in series or in parallel, or may be used to feed three separate circuits.

(TO BE CONTINUED.)

* Discs of thin iron for a similar purpose are found in the dynamos of Jablochkoff, Weston, and Gülcher.

* The Bürgin armature exhibited on the evening of the lecture was kindly lent by Messrs. R. E. Crompton and Co.

EASTERN TELEGRAPH COMPANY (LIMITED).

The twenty-first half-yearly ordinary general meeting of this Company was held on the 25th instant, at the City Terminus Hotel, under the presidency of J. Pender, Esq., M.P.

Mr. Lewis Wells having read the notice calling the meeting,

The Chairman moved the adoption of the report and accounts, and after referring to the full information contained therein, stated that the revenue for the six months ended 30th September last had been £341,151, against £282,834 in the corresponding period of 1881, being an increase of £58,317. Analysing these figures, they found a very satisfactory growth of the traffic throughout their system, with one or two exceptions. The ordinary expenses of the Company had amounted in the half year to £69,809, which was an increase of £2,311, as compared with the corresponding half of 1881. The main cause of this increase was their having opened four new stations at Athens, Karystos, Trieste, and Corfu, and they had had increased expenses owing to the increased volume of the traffic from Egypt and other places during the war. The repairs to the cables, &c., had cost £52,801, which was an increase of £5,573. Full particulars were given in the accounts in Abstract "C" of this expenditure. Of course this exceptional expenditure would be always more or less fluctuating. The general expenses in London had amounted to £6,670, or an increase of £149. The working expenses at the stations had amounted to £50,387, or an increase of £2,969, as compared with the same half of 1881. The opening of the four new stations had caused the great bulk of the increase. The amount carried forward in that half year would be £56,836, or £27,332 more than in the corresponding half year. This was after paying a bonus of 1s. per share on the ordinary capital, making with the previous payment a return for the half year at the rate of 6 per cent. per annum. Up to the present time they had been in the habit of paying a dividend at this period of the year at the rate of 5 per cent., leaving the bonus for the end of the year. But they were so satisfied with the position of the Company that they thought they might give a proportion of the bonus this half year, and he hoped when he met them next half year that they would be able to state that the dividend had been 6 per cent. for the year. He then reminded them of the breaks or interruptions in their system to which he had alluded at the previous meeting, and said that they had since been effectually repaired. One very important interruption in the Bay of Biscay had been rectified, the cable having been picked up from 2,700 fathoms of water, a fact which proved that they had what he had so often maintained—a property. He stated at the last meeting that they were in a very peculiar position with regard to their ships, as it was their duty to maintain, if possible, telegraphic communication between Egypt and England. This had been accomplished satisfactorily from a commercial point of view to themselves, and satisfactorily also as regarded broad national interests, and they had received an ac-

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knowledgment from the Government of the services rendered by the Company during the recent war. He next referred with satisfaction to the communication by cables which had been established between Alexandria and Port Said. Thus, thanks to the Government and the broad views of the Khedive, they had been able to make an arrangement with the Suez Canal Company, by which, in future, they would have an alternate line along the Suez Canal, connecting the Suez end with India and the Port Said end with Egypt. After commenting on the importance of this operation, he alluded to the eventful period which the last half year constituted in the Company's history, and observed that, notwithstanding the ups and downs and the interruptions to their Indian traffic, the receipts in the half year had been the largest that they had ever had. He next referred to the views enunciated at the last meeting with regard to the services which the staff in Egypt had rendered, and stated that the Board had recognised those services by a money grant, which would be an incentive to the officers on any future occasion.

The VICE-CHAIRMAN (the Marquis of Tweeddale) having seconded the motion,

A brief discussion followed, in the course of which the zealous services which had been rendered by the staff generally, and particularly in Egypt, were warmly acknowledged by several speakers.

The CHAIRMAN, at the close of the discussion, stated that they would take advantage of a favourable opportunity (and circumstances were tending in that direction, the Bank rate having been reduced) to replace their debentures, and, of course, they would do it at the cheapest possible rate. He entirely concurred with the remarks made as to the advisability of replacing to reserve fund the amount which had been taken from it, a strong reserve adding very greatly to the stability of the Company. He expressed his pleasure at the eulogistic remarks which had been made regarding the services of the staff, and assured them of the hourly services which had also been rendered necessary from the Board. With regard to the proposal to increase the remuneration of the directors, on behalf of his colleagues he could say that they were satisfied at present, but when the time came they would not oppose such a proposal.

The report was unanimously adopted, and the retiring directors, Lord S. A. Cecil and General Lord Alfred Paget, were re-elected, as were also the auditors, Mr. Henry Dever and Messrs. Quilter, Ball, and Co.

A cordial vote of thanks to the chairman terminated the proceedings.

We shall publish a full report of this meeting in another issue.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

An extraordinary general meeting of this Company was held on the 25th inst., at St. Michael's Hall, George-yard, Lombard-street.

Major WOOD having read the notice calling the meeting,

Sir H. D. WOLFF, M.P., who presided, moved the confirmation of the first of the special resolutions passed at the meeting on the 10th inst., the effect of which was to reduce the capital of the Company from £1,398,200, divided into 69,910 shares of £20 each, into £1,048,650, divided into the same number of shares of £15 each.

Major WOOD seconded the motion, which was carried.

The CHAIRMAN then moved the confirmation of the resolution, substituting for Article No. 40 another Article similarly numbered, authorising the Board to appoint a managing director who might be a member of the Board, but who should not be subject to retirement by rotation.

Mr. H. WEAVER seconded the motion, which was carried.

Mr. PIKE said, with regard to the last resolution, that he would not repeat the arguments that he had used on a former occasion, but he thought everyone would be willing to recognise the great services which had been rendered by the Board, and there was no doubt that the best way to do so would be by allotting them in the way in which he (Mr. Pike) had suggested a certain number of the shares recovered. He might point out this fact—that before the directors could fight the battle successfully, as they had done, they had to displace the old directors, and, if there was no other circumstance in their favour, that alone would entitle them, he contended, to some substantial acknowledgment at the hands of the shareholders. He then moved the following resolution:—"That in view of the great services of the Board in relation to the late litigation, by which a very large sum of money has been recovered for the Company, and the Company placed on a sound footing, and as a recognition by the shareholders of the successful result of their labours, the directors be requested to accept 700 of the shares acquired by the Company as part of the settlement, and now held by trustees for the Company, to be divided among the members of the Board as they may determine."

Mr. SUTTON, in seconding the motion, said that the action of the Board had resulted in the recovery of £150,000, which was previously absolutely lost. This amount would not have been recovered, he contended, but for the great skill and diligence displayed by the directors. He, therefore, thought that the directors for having recovered such a substantial sum should be suitably rewarded by the shareholders. The amount proposed to be given them was only equal to £5,000. Some gentleman had thought that the amount should be only £3,000, but no doubt that gentleman would agree that the extra £2,000 which was proposed by Mr. Pike's resolution would not make much difference to a large company like theirs, which he had no doubt was about to enter on a career of prosperity.

Mr. GODFREY opposed the motion, and said it must be remembered that for four or five years the shareholders had been without a dividend, and in that way alone there had been a loss to them of between 20 and 25 per cent. In addition to that the market price of the shares stood at more than 60 per cent. discount. The chairman and directors had received their salaries for doing their duty, and he did not think they had done more than their duty. Under these circumstances he should be happy to see some of the directors themselves decline to assent to the proposal.

Mr. GADESDEN also opposed the motion, and argued that the real work in connection with the litigation had after all been conducted by the solicitors, counsel, officers, and others. The whole of the costs of counsel and everything in connection with the case was under £5,000, whereas it was proposed to vote the directors a similar amount for really doing next to nothing in the matter.

Mr. WARING supported the motion.

Mr. GADESDEN moved an amendment to the effect "That the number of shares to be given to the directors should be 350."

Mr. WALTON seconded the amendment.

The CHAIRMAN put the amendment, which he declared lost. He then put the original motion, and declared it carried, stating that 18 had voted for it, and 14 against it.

The proceedings then terminated.

ORIENTAL TELEPHONE COMPANY (LIMITED).

An extraordinary general meeting of the members of this Company was held at the City Terminus Hotel, on the 24th inst. J. Pender, Esq., M.P., presided.

The CHAIRMAN, in opening the proceedings, said: Gentlemen, the secretary will read the notice convening the meeting.

The SECRETARY accordingly read the notice and subsequently read the minutes of the last meeting—the extraordinary general meeting held at the offices of the Company on the 4th ult.

The CHAIRMAN: Is it your pleasure that those minutes be signed? Those in favour say Aye. To the contrary No. The ayes have it. Having signed the minutes, he continued: Gentlemen, this is a special meeting called for the purpose of altering the Articles of Association. When I last had the pleasure of addressing you I referred to the great progress which the Company had made. I also referred to the fact that we were in negotiation with parties in Bombay for the formation of a company. That has been completed. It requires after the end of the year two or three months—in fact, three months—before we can get home all the accounts and submit our annual balance-sheet, and therefore we thought, as some applications had been made by different shareholders as to dividend, that it would be desirable we should have the power to declare interim dividends. We had the money, and therefore we thought, as these articles must be introduced into our articles to enable us to pay interim dividends, that it was as well to do so at once, and at the same time pay an interim dividend, which we propose to declare. That is the object of the meeting, and the first resolution I have to submit is as follows:—"That the Articles of Association of the Company be, and the same hereby are altered by rescinding Article 48, and that in lieu thereof the following article shall henceforth be Article 48, viz.:—'48. Every member shall have one vote for every share held by him, and every holder of a share warrant shall (subject to the provisions of Clause 23 being complied with) have one vote for every share warrant held by him. In case of an equality of votes at any general meeting or poll, the chairman shall be entitled to a second or casting vote. That is one article we propose to alter.'"

Mr. P. CARNEGY, C.I.E.: I beg to second that resolution.

The CHAIRMAN: If any gentleman has any remark to make before I put that resolution I shall be glad to hear him. According to my idea it is merely making some amendment in the Articles of Association, which, probably, would have been better had they been done in the first instance. Those in favour of that resolution please hold up their hands. To the contrary. Carried unanimously. The next resolution is as follows:—"That the Articles of Association of the Company shall be, and the same hereby are altered by the following article being inserted after Article 79, viz.:—'79A. The directors may of their own authority from time to time determine on, and declare an instalment to be paid to the members in proportion to the amount paid up or deemed and taken as paid up upon their shares on account, and in anticipation of the dividend for the current year, but so that the aggregate amount of such instalments in any one year shall not exceed a dividend at the rate of 20 per cent. for the year.'"

Colonel GOURAUD: Mr. Chairman, I have great pleasure in seconding that resolution. The terms of it are so obviously in the interests of the shareholders that I do not think any special remarks from me are necessary.

The CHAIRMAN put the motion in the usual way, and declared it carried unanimously. Continuing, he said: The next resolution is as follows: "That the Articles of Association of the Company be, and the same hereby are altered by rescinding Article 82 of the Articles of Association of the Company, and that in lieu thereof the following article shall henceforth be Article 82, viz.:—'82. Every dividend and instalment of dividend or interest shall belong and be paid (subject to the Company's lien) to the members who shall be on the register at the date when such dividend or instalment of dividend shall be declared, or interest shall be payable, notwithstanding any subsequent transfer or transmission of share.'"

Sir A. ARMSTRONG: I beg to second that.

The CHAIRMAN put the motion, and declared it carried unanimously. Continuing, he said: Now, gentlemen, these resolutions have to be confirmed, and when that is done we shall be in a position to declare an interim dividend. We are not in a position to declare an interim dividend until once those articles are confirmed at another meeting. We must go through the legal form, and that other meeting will be held as soon as it can be legally. At that meeting the dividend will be declared.

The SOLICITOR: These resolutions will be confirmed, and then the dividend can be declared.

Colonel GOURAUD: The confirmation being necessary by the Articles of Association?

The CHAIRMAN: Yes, that will enable us probably to pay this dividend within the next fortnight or three weeks. Had we delayed altering these articles until April, the chances are that you would not probably have had a dividend before May. In this way you will probably have a dividend in the next fourteen days. I may say in passing that I hope by the time I have the pleasure of addressing you in May we shall have the pleasure of announcing that in Egypt we have established another company on a very satisfactory basis. Alexandria, even since I last addressed you, has advanced in such an encouraging way that I think we may look forward to a very good Exchange being established there. The Government have taken it up, and I think when Alexandria has been reorganised and rebuilt we may look for a very satisfactory state of affairs there. In other parts we have taken up—Singapore, and so on—they are all progressing very much as I stated when I last addressed you. I regret the necessity of your attendance to-day, and that you should have been put to the trouble of coming, but different solicitors have different ways of dealing with Articles of Association. I thought the directors had the power of declaring interim meetings. The article in which I thought we had

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that right says "dividend or dividends," and I thought "or dividends" meant that we could pay interim dividends. The lawyers, however, differ, and we, therefore, thought it better that you should be called together, so that there might be no doubt on the subject. That closes the business of the meeting, gentlemen.

The meeting then separated.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED).

The ordinary general meeting of this Company was held at the City Terminus Hotel on the 23rd inst., under the presidency of Sir H. W. Tyler, M.P.

The SECRETARY (Mr. Wm. J. Cordner) having read the notice convening the meeting, the report, of which an abstract has appeared in the *Electrician*, was taken as read.

The CHAIRMAN, in moving its adoption, stated that their last meeting was held on August 2 last year, and it was a very miserable one. The directors then called the shareholders together in order, with their permission, to pay a very large dividend, and they felt that the circumstances of the Company were not very likely to contribute to the pleasure of the directors, because there had been before that time a mania for speculation, and every one occupying the position filled by the directors knew that after such a mania, and after the shares had been run up to such a price as this Company's had been, there must naturally come some reaction and disappointment. That reaction had been even more severe than one had imagined, and there must have been very serious and great disappointment among those who purchased shares in the Company at the very high prices they were run up to. On the present occasion the task of the directors was more congenial ["oh"], because they had to reply to the accusations which had been so freely launched against them; and their duty now was not to counsel investors, but to uphold the credit of the Company before the world. Passing to the report and balance-sheet, he called attention to the list showing the expenses, commissions, charges, &c., for the year 1882, as to which one of the charges most freely launched against them had reference. The first item was the salaries account £35,868, including the directors' fees, £25,896. Well, that was a large sum, but it was only what they were authorised to receive by the Articles of Association in proportion to the dividend paid to the shareholders; and he only wished, for their sake, they could that day declare another 100 per cent. dividend, when the directors would be entitled to similar large commissions. He had no doubt that if the directors could have foreseen the grave reaction which had since taken place they would not have taken the fees which they took last autumn. They would not draw their fees for the present half year, and he had suggested to his colleagues that they should draw no further fees until they had paid a dividend of at least 10 per cent. to the shareholders. As regarded the miscellaneous charges, £2,740 had been incurred on account of experiments in the manufacture of carbons, for at one time they had found very great difficulty in getting suitable carbons. It included what they had paid for gas and water, office charges, &c. Coal account, £1,543, was not very heavy, considering the very large works going on at their three large establishments. Carriage account, £3,674, seemed a large sum, but that was on account of their apparatus and machinery carried to and from all parts of the world; and a very large portion of it was charged to the carbons, which they received from Cleveland, America. The law charges might seem heavy—£3,763, but not much more than half of that was for law charges proper, a good deal having been paid in fees to counsel and in retainers to scientific witnesses. They had, however, been threatened with actions, and an action was pending against them by the Gramme Company, who claimed that the Brush machine was an infringement of the Gramme patent. They had no doubt they would defend the Company successfully in that action. The rates and taxes, £2,860, they could not help. Continental and travelling expenses seemed heavy, but they had been obliged to employ gentlemen travelling about the continent continually in connection with their concessions; and to make the patents valid on different parts of the continent they were obliged to manufacture the apparatus in the different capitals. The Crystal Palace Exhibition had cost them £4,869. He did not think any of them would consider that the money of the Company had been spent wastefully at the Crystal Palace Exhibition. They had thought that, if done at all, it ought to be done creditably, and it had been, and had done the Company good. As to the lighting contract account it had been said that the Company had lost £1,596 in the year there, but those who made that statement forgot that that amount represented only the charges in connection with these contracts, forgetting to put the receipts from the contracts against the charges. The last item was £39,791, "commissions and special discounts on sales to licensee companies, as per agreements." They had thought that that was pretty fairly stated, but they had been told that it was a dreadful item, and that there must be a great deal of jobbery in it. It was, however, made up of discounts on sales of apparatus to the sub-companies, on whose purchases they allowed a discount of 20 per cent., and in some special cases even more. Altogether there was a total of £102,832 for all their expenses, commissions, and charges for the year. In a note they stated that they divided that sum into two, because there were separate charges. Of the total amount £58,029 was charged to the statement showing the amount realised from the sale of concessions, and the balance was charged on the other side of the balance sheet to manufacturing account. As regarded the balance-sheet the great feature was the value of their property, and the value of the stocks now in their possession. The value of the property, including the plant at their Victoria, Borough-road, and Portpool-lane works was £66,491, and the value of the stocks at these different works was £93,034, making together in round figures £160,000. That was a large amount, but in the last half of last year there was a very great demand on them, and they had to increase their previously existing manufactures, and to get additional premises to enable them to do so. They had now got in their factories as fine a set of machinery as they would wish to see anywhere, and they had the very large amount of stock he had mentioned. He supposed they would all agree that the electric light was coming into fresh play again when the Act came into force, and then the companies working with them would send in their orders. If it had not been for the sudden stoppage of the sale of their apparatus they would, he said, have been able to declare a very handsome dividend that day. As to their plant, if the electric light were to stop their plant was valuable for manufacture of every description. He did not think that what had been done would be other than beneficial to the Company. There was an item of £50,000 due from Mr. Lane-Fox, which he had undertaken to pay them by March. They proposed to write off 10 per cent. for depreciation of plant and buildings, and £132,950 off the purchase price of the patents—a sum representing the amount they held in shares. Some of these shares might not possess much value, but others they believed to be very valuable. That would be the best way to deal with these shares, as to carry forward the amount they represented would make the balance carried forward look so very large. The original shareholders, too, had no reason to be dissatisfied, as they had had all their money back and something beyond. Let them look at what the Company had done. The Company had been in existence only two years. Out of the first year's work they were able to divide out of manufacturing profits 12½ per cent., and to set aside £90,000 to reserve. In the course of the next half year the great speculation sprang up, and every one went in for electric lighting shares. The directors at one time were almost "torn to pieces" by people who insisted on buying concessions from them in every part of the world. They did the best they could under the circumstances, and the result was the distribution of 100 per cent. dividend to the shareholders. They thought they did right in making the distribution, but they were now told that, having regard to the present position of the Company, they ought not to have distributed so large an amount among the shareholders, and a great many reasons—some of them not very complimentary—had been assigned for their doing so. As to their reasons for doing so, in the first place they were glad to be in a position to pay back to every gentlemen whatever he had invested in the Company; but the real reason why they were anxious to distribute the money was this: The £4 shareholders were the most numerous in the Company, and had the voting power, and the directors had been very seriously threatened that they would be forced into making a call on those shares, which were at a very high premium. If the directors had been forced to call up £6 on them, the shares would have been worth something like £60, and a very large premium would have been realised on the amount so called up. In order, therefore, that there might be no further dissension between the £10 and the £4 shareholders, the directors decided to divide all or nearly all the money they had in hand. The threat of forcing them to make a call was a very serious danger, and they decided to avert it. Since then, unfortunately, the directors had been obliged to make a call, as they found orders did not come in. They had very large manufacturing establishments and a very large and increasing stock, which did not go off. For these reasons they had had to make a call, and now the very persons who before so anxiously desired that a call might be made were the first to cry out against it. Well, now, having gone through all this, let them start afresh, and he believed there was a very good future for the Corporation, with their magnificent stock all ready to turn into money as soon as the tide turned again in favour of electric lighting. After referring to the attacks made on them by certain sections of the Press, he observed that it had been stated that the Company was subject to a great deal of litigation, and that they would have to give up in litigation all that they had swallowed. He was, however, happy to inform them that there was no litigation in which they were engaged which need give them any concern. A very troublesome matter which had cropped up was a mistake which had occurred in the prospectuses of some of the sub-companies. A great many statements had been made on the subject, to which they had paid little attention, and they had felt a delicacy in dealing with it, not wishing to make the difficulties of those who had fallen into the mistake any harder than they were. The present, however, was the opportunity for him to state the exact position of the Company in the matter. They had sold the Brush concession for various parts of the United Kingdom, and, at the same time, they sold, or rather gave away the license for the Lane-Fox lamp. Mr. Lane-Fox, before he came to this Company, had dealt with the British Electric Light Company, and, not finding his dealings with them satisfactory, he paid that company a considerable sum of money to get back his patents, allowing the British Company, however, to use his lamp without his name. Then Mr. Lane-Fox came to deal with this Company, and they made an arrangement with him paying him a certain number of shares, and arranging to pay him a proportion of the profits of manufacture, and half the profits on the sale of the foreign patents. When, however, they came to deal with the patents for the Lane-Fox lamp in this country, they did not feel themselves justified in selling the Lane-Fox licenses, because they felt that they were not exclusive. They sold the Brush patents for a certain sum of money for different parts of the United Kingdom, but they gave the license for the Lane-Fox lamp without any payment whatever. Unfortunately, when some of the prospectuses were issued of the sub-companies, and they were got out in a great hurry, the word "exclusive" slipped into them as applied to the Lane-Fox license. How it did so it was not for him to explain. They knew nothing of it till the matter was made public, when a great fuss was made about it. They, however, had nothing to do with it. At the present meeting there were certain dissensions—two classes. A circular had been sent round, signed by Messrs. Gillitt, Pigott, and Noel, and Mr. Lane-Fox had also been very active. The directors had already had some negotiations with Mr. Gillitt and two other gentlemen—Messrs. Delamere and Bedford, whom they had requested to nominate a director. The directors wanted to get some large shareholder in the concern with them. Mr. Lane-Fox was in quite a different category. That gentleman ought to be working with them as one of them, and not against them, but knowing that the Company was subject to some attack at that meeting he had been preparing to take advantage of the position. He had contracted—the arrangement was not the seeking of the directors—to pay the Company £50,000 next March, buying back a certain portion of his license, leaving the Company, however, with all that would be necessary for their purposes. Finding that this was a little onerous, Mr. Lane-Fox had come to the directors and had asked them to set off what little matters might be in account in his favour with the Company against this £50,000, and he had told them that he should make matters very disagreeable if they did not do so. They had declined his proposal, and the result was a letter which had been freely published in a great many newspapers. After quoting from this letter, he stated that the present instance was the first he had known of a gentleman who was working with, and had com-

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plicated transactions with a company, taking advantage of a time of attack to serve his own private interests. The directors, however, were not the men to shrink from a difficult position. He concluded by moving the adoption of the report and balance-sheet.

The VICE-CHAIRMAN (Mr. J. S. Sellon), in seconding the motion, said there was no doubt that the true policy to pursue was for all interested in the Company to pull together in unison. His impression was that it would be as much use to try and stay the wind as to stop the future of electric lighting. Persistent statements had been made to the effect that the patents of the Company were worthless. He, on the contrary, did not hesitate to assert that they possessed some of the most valuable and most comprehensive electric light patents that existed. He would go so far as to express his firm belief that in the Brush patent they had the foundation of all successful and economical electric lighting; also that the patents were not only unassailable, but that the principles which were effectually protected under them were so essential to the success of electric lighting that no system which did not embrace them could hope for success. He then referred to the futility of the efforts so far made to supersede the Brush patent; and as to the durability of the Brush machine, the work had been carried on in the City for the last two years by one machine on which not 5s. had been spent for repairs. He looked forward to the time when lighting, heating, motion, and metallurgical operations would be carried out by the aid of electricity. He explained his reasons for his prejudice against alternating current machines, and added that he had no fear of their competition. He maintained that, in low tension machines, the Brush could successfully compete with any other, and that, in those of high tension, which were alone suitable for long range work, they had practically no competitor.

Mr. GILLITT expressed the disappointment he had felt on looking at the accounts. They could not disguise from themselves that there had been a wide-spread feeling of dissatisfaction, suspicion, and distrust with regard to the Company, and he should not be satisfied without a committee of inquiry. He referred to the principles enunciated by the chairman at former meetings, and maintained that they had not been borne out subsequently. What he wanted to see now was the real position of the Company, and it was that which he believed would tend to dispel all the feeling of distrust which had been engendered. He might state that all the gentlemen with whom he had been connected were largely interested in the Company, and were strongly in favour of electric lighting, more especially the Brush system. The whole success of electric lighting was, he believed, largely dependent on the public opinion of the country, and they must therefore remove all doubt. He moved as an amendment "That a committee of shareholders be appointed to consider and report on the affairs, position, and general conduct of the Corporation."

Mr. ROBERT ALSOP seconded the amendment.

Mr. LANE-FOX stated that if the amendment were accepted he would defer any remarks he might have to make.

The CHAIRMAN: Mr. Lane-Fox may proceed with his statement.

Mr. LANE-FOX proceeded at some length to criticise the policy of the directors. After strongly repudiating the statement of the chairman that he was now taking advantage of the present position of affairs to serve his own purposes, he stated that it was at Mr. Sellon's solicitation that he first joined the Company. They paid him £5,000 in shares of the Company, with which he took a liability of £7,500, and just previously to that he had paid £5,000 cash to the British Electric Light Company to sever his connection with them. His license to that company was inalienable, and they were not to use his name. The chairman had stated that he ought to be co-operating with the Company. He had repeatedly, in writing too, offered to assist them in every way, but his offers had been repelled. On one occasion he attended a Board meeting to protest against the way they were proceeding, and he was then told by Sir Henry Tyler that they did not believe in incandescent lighting, that it was impracticable, and that the money which had been spent on it was being wasted. That was the opinion of the chairman, but he (Mr. Lane-Fox) was convinced that incandescent lighting was likely to be the most important branch of the business in the future. As to his financial relations with the Company, some of them might suppose that he had made large sums out of the Company. If he were quietly to accept the directors' statement of accounts he should be a loser of £40,000, notwithstanding that he was entitled to half the profits on the foreign concessions, and 25 per cent. of the profits on the English. He maintained that it had been chiefly in virtue of his name that the sub-companies had been floated. Some of the directors had joined the sub-companies, and in their prospectuses his inventions were stated to be most valuable. The directors had, however, told him they had received nothing from those companies for his licenses, and that therefore his share was nothing. When he saw that very little good was being done by the directors with his patents, he agreed to take them back for £50,000, a sum which he considered was far more than covered by the amount owing to him. About three months ago he was preparing a legal action to be brought against them, but when he discovered their deplorable condition, and that the boasted sums that they had in hand did not exist, he felt that he should do no good to them by bringing the action: and he therefore had offered the directors a compromise. His chief object, however, in addressing them that day was to maintain that the continuation of the present policy of the Board would be utter ruin, and he urged them to take advantage of the opportunity to prevent the disaster which would otherwise come. Contrary to what the chairman had stated there was now an enormous demand for electric lighting, which was likely to be far greater in the future; and so far from the Electric Lighting Act being prejudicial to the Company, as the directors had intimated in the report, it was of enormous assistance to them. They must turn their attention to legitimate work, and if they would know more about the matter he would advise them to read the article on "Wholesale Electricity" in *The Times* of the previous day (last Monday). Let them turn their attention to the class of work indicated in that article, and he believed there would be a grand future before them.

Mr. Alderman WHITEHEAD, in a speech of some length, imputed no want of integrity among the directors, but want of judgment in the best interests of the Corporation. He dealt fully with and criticised various items in the accounts, and stated that he made out that the real tangible securities of the Company represented £302,268, and that instead of a surplus of £109,368, they had a deficiency of £56,311. He supported the proposal for the committee, and stated that it was within his own knowledge that for five months at least the sub-companies had been trying to get from the Company dynamos suitable for incandescent lighting. So hopeless had the Board become in the matter that they had at last agreed that the dynamo of another inventor might be used by the sub-companies.

The CHAIRMAN: That is not true.

Mr. OFFOR, who said he was the manager of two sub-companies, stated that the experience of his companies was that the most important branch of their business would consist of incandescent lighting, and they had also arrived at the conclusion that incandescent lighting was practically impossible without a storage system. He must endorse the remarks which had been made as to their inability to obtain from the Brush Company a machine which would enable them to go on and bridge over the short time before the granting of the provisional orders.

Mr. WM. ABBOTT stated that if anything would have induced him to support the amendment it would have been the moderate tone in which it was brought forward by Mr. Gillitt, but his experience was adverse to committees of investigation, and it was decidedly so on the present occasion.

Mr. DASHWOOD supported the amendment.

A SHAREHOLDER, whose name did not transpire, also supported the amendment, and observed that when the Hudson's Bay Company disposed of land, the money so obtained was distributed among the shareholders as return of capital. If the directors had treated the sale of the concessions in the same way they would not have been able to take for themselves the £25,896 which they had had in fees.

Mr. T. SUTHERLAND agreed in condemning the financial management of the Company, but he was strongly opposed to the appointment of a committee. The effect of that might be that the directors would resign, and the affairs of the Company would come into the hands of men ignorant, perhaps, of the business which was to be conducted.

Mr. PHELPS pointed out that the object was not to turn the Board out.

The CHAIRMAN, in reply, at the close of the discussion stated that in virtue of what he held in the previous company he held a number of shares in this Company. He had sold them, wanting the money for other purposes, and had sold them at comparatively low prices. Had he held for high prices he should have been £30,000 richer than he was. Independently of that, he had never bought or sold a share in any electric light or storage company. As to the serious question raised by Alderman Whitehead as to their inability to supply machines for incandescent lighting, and that his (Alderman Whitehead's) company had used another machine of another company to light some place in the metropolis, he (the chairman) had made some inquiries into the matter, and had found that the Metropolitan Company as a special favour had been allowed to use one of Siemens's machines to light Willis's Rooms with the Swan lamp, and he had been informed that it had broken down twice in the course of the evening. There was no disguising the fact that their balance at the bank had been largely overdrawn. If not they would not have made the call. Mr. Lane-Fox had stated that they had never provided for incandescent lighting. He was surprised at such a statement. The shareholders had no idea of the exertions they had been making to improve and perfect incandescent machines for incandescent lighting, and they had been grieved beyond measure that more progress had not been made. That, however, was through their having trusted Mr. Lane-Fox too much at the Portpool-lane factory. A man had been placed there by Mr. Lane-Fox, who had himself eventually admitted that he could stand him no longer. As to his having said that he did not believe in the incandescent lighting, he had always had the greatest admiration for it, but what he had always said was that it was very difficult to make incandescent lighting pay. With regard to a committee, they were free to look into the books of the Company and into the affairs of the Company generally if it were to the interest of the Company; but the directors would decline to consent to a committee of investigation which would afterwards make a report, and so expose to rival companies, and to the world in general, all the Company's trading accounts. If the committee were carried against them they would be happy to resign their positions. He then put the amendment, and declared that 86 had voted for it. Having put it to the contrary he announced, amid hisses, that it was not carried.

SEVERAL SHAREHOLDERS: "Give the numbers."

The CHAIRMAN: It has been suggested to me that the meeting did not know on what they were voting ["Give us the numbers."]. He made them 86 for and 60 against the amendment. They would put the amendment again [no, no].

Mr. GILLITT said that the ruling of the chairman was entirely wrong. He had stated that the numbers were 86 for and 60 against the amendment. How, therefore, could he say that the amendment was not carried? He must declare in accordance with the show of hands.

The CHAIRMAN stated that he had been guided by the solicitor's advice. He ultimately declared the amendment carried.

A poll was then demanded on behalf of the directors, and it was arranged to take it that day week (next Tuesday) at the City Terminus Hotel between two and five o'clock.

The proceedings then terminated.

YORKSHIRE BRUSH ELECTRIC LIGHT AND POWER COMPANY (LIMITED).

An extraordinary general meeting of this Company was held at the Cannon-street Hotel, on the 19th inst., "for the purpose of considering an offer for the repurchase from this Company of the Lane-Fox license, for the sum of £35,000, payable in fully paid-up shares of this Company, and, if then considered desirable, passing resolutions authorising the Board of this Company to carry out a sale of the said license upon the above terms, or such other terms as the meeting may decide." Mr. H. W. Lowe presided.

The secretary, Mr. GEO. L. MORTON, having read the notice convening the meeting,

The CHAIRMAN said: When I last addressed you I mentioned that the directors would take the opportunity of doing the utmost in their power to bring about a fair settlement of this question of the Lane-Fox patents. Since that time they have been very actively engaged in trying to make

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terms for this purpose. I need not tell you that this has occupied a long time, and that it has been a very wearying, anxious time for us to bring this matter to a settlement. We had many conflicting actions going on at the same time, which occupied our time also to a great extent. However, we pushed persistently on with the object of bringing this matter to some settlement, and so soon as we obtained what appeared to us a reasonable proposal we immediately decided to submit it to the consideration and discussion of a general meeting, in accordance with the promise I made at the last meeting that we would not make any final arrangement unless with your sanction and approval. In the circular which you received accompanping the notice calling this meeting we have told you the terms proposed, and at the same time we took the opportunity of inviting those shareholders who would not be able to be present here to give us their views so as to enable us to obtain some idea of their opinion. The concensus of these opinions is this—that the amount of the proposal is considered fair and reasonable within certain limits, but they one and all mention that it is considered highly essential that it should be accompanied by a money payment. The directors themselves have also been very much impressed with this idea from the beginning, and we have held it well in view in our negotiations, but they have been unable to obtain a proposal of a cash payment included in that of the transfer or cancellation of the shares. We can discuss the matter to-day, and whatever you decide on we shall try and carry out to the fullest possible extent. If any shareholder will favour us with his special views on the matter now before us we shall be glad.

Mr. C. PERRY WHITELEY requested that the original letter containing the offer might be read.

The CHAIRMAN: We have not brought with us the original letter. The offer was made on behalf of the Electrical Works Company to buy back the Lane-Fox license in consideration of the sum of £35,000 in paid-up shares in this Company. The letter was the result of all the negotiations that had been going on before, put in a definite shape. Replying to further questions he stated that the terms of the prospectus were carried out as to the vendors, who received £50,000 in cash and £50,000 in paid-up shares. That included the Brush and the Lane-Fox licenses—everything. They paid nothing specifically for the Lane-Fox license. The exclusive right of the Company to use the Brush dynamo was never disputed; but, because the two were lumped together, and the exclusive right was given as to the Brush dynamo, it was assumed that the Lane-Fox license was also exclusive. The practical value of the Lane-Fox lamp was *nil*, as, by the Electric Lighting Act of last Session, any consumer could demand to be supplied with any lamp he chose. If, however, they retained the Lane-Fox license they might lose business, as, by their concession, they were bound to supply the Lane-Fox lamp solely. The offer under consideration had been made on behalf of the Electrical Works Company, who were the nominal parties to whom the Company had to look, but the real parties were the Hammond Company.

Mr. WHITELEY intimated that he should object to the offer as being totally illegal, for the reason that the Electrical Works Company were in liquidation and could not make such an offer. He was very glad to hear that the real parties the Company had to deal with were the Hammond Company. He then referred to the petition he had presented for winding up this Company, and afterwards read the affidavit of Mr. Brown, observing that, if the statement it contained were true, the Company actually did possess an exclusive license to the Lane-Fox incandescent lamp, in which case his petition would fall to the ground, and there would be an end of the matter. If, however, the affidavit were true, why was this offer to the Company continued? Why was it not withdrawn? Why were the vendors so anxious to give them back £35,000? Again, if it were true, what was the effect of the proposal before the meeting? To give up, for a few shares, practically the only thing the Company had got, and for which they gave £100,000. They would then be left solely with the Brush machine, which, from what they had heard from the Hammond Company, was superseded by the Ferranti machine.

Mr. GUEDALLA (of the firm of solicitors who signed the letter containing the offer) stated that Mr. Lane-Fox was prepared to make an affidavit in support of Mr. Brown's. Hence it appeared clear that the Company had acquired the exclusive right to the Lane-Fox lamp. He was prepared to prove that whatever the vendors had received from the Company had been in shares, and that they were absolutely out by £5,000, their deposit in the first instance to the Hammond Company, which had never been returned to them in any form but shares.

The CHAIRMAN stated that that matter was not relevant to the question before the meeting, and that Mr. Guedalla was out of order.

Mr. GUEDALLA, continuing, stated, in reply to the question asked by Mr. Whiteley, that the offer was kept open notwithstanding the statement in the affidavit of Mr. Brown, in order that any difficulty might be got over, the law proceedings abandoned, and that the Company might continue its work.

The CHAIRMAN stated that the transfer of the Lane-Fox license would not prevent the Company from supplying Lane-Fox lamps, as they could get them readily from the Hammond Company, who would gladly supply them as a matter of business. As to the vendors having received no cash, they could not go into matters as between the Electrical Works Company and the Hammond Company. They must go by their records, and they showed that on the 11th July it was resolved that £50,000 in cash be paid to the Electrical Works Company in two cheques of £10,000 and £40,000; and on the 14th July it was resolved that, in accordance with the agreement, the sum of £50,000 and £25,000 fully paid-up shares of the Company be paid to the Hammond Company. As to the progress of the Company, that was continuing in the most satisfactory manner, at Middlesbrough particularly, and at Dewsbury, Huddersfield, and at other places; and they had also made some small installations at Leeds. They had tenders now before them from several important corporations and local bodies, but, of course, the disagreeable position in which they had been placed through the recent action of some of the shareholders had done them considerable harm. The inquiry had been made of them on the part of certain corporations—"What security have we if we give you orders that they will be executed? We hear you are going to be wound up." They were perfectly confident, as they had replied, that they would get the petition dismissed, and the threat of being wound up did not frighten them in the least.

Mr. M'ALISTER observed that the Brush patent appeared to be valueless, and they were asked to part with the Lane-Fox license for £35,000 not in cash, but in shares, and what was their value?

Mr. ROBERT HAMMOND: Holding the intermediate position I do in this matter, you can easily understand my anxiety that I should not take up points which may fairly be called disputed points between the various vendors who were interested in the formation of the Company. There have, however, been two things said here which force me on my feet. I take it that, though the chairman has ruled Mr. Guedalla out of order in raking up this matter of the shares, it is a fair thing to say when it is asked "Why do not these people give us back our cash?" that, as a matter of fact, they invested all the money they got from the Company in the shares of the Company. As a matter of fact, the whole cost of floating the Company and the cash paid to them is represented by shares in this Company. To my mind there is nothing whatever against such a proceeding. They had the option of walking off with £50,000 and spending it or investing it in the shares of the Company; and, if they did invest it in the shares of the Company, who is the loser? As to the allotment on an insufficient subscription, of course I had personally to do with the particular figures connected with the formation of the Company. A figure was agreed on as to which we should go to allotment. I have considered all through that a margin of £25,000 to work the Yorkshire business was amply sufficient. As you know, for some time I conducted on my own resources the business which has been taken over by the Hammond Company, and when that company came out we considered that £40,000 was sufficient capital for the whole of their concessions; and if £40,000 was sufficient to conduct the whole business of the Hammond Company for the whole of their concessions it cannot be considered that £25,000 was too little for the portion of its business in Yorkshire.

Mr. M'ALISTER: Why did you ask for £200,000, then?

Mr. HAMMOND: The amount at which the directors were allowed to go to allotment was £25,000, and they did so. As to the business of the Company, there seems to be a notion that the Hammond Company is antagonistic to the Company. That is quite wrong. The Hammond Company and the Yorkshire Company, to all intents and purposes, as far as interests are concerned, are one, and whatever comes to the Hammond Company, it will be the desire of the Hammond Company to pass on to the Yorkshire Company, and if the Yorkshire Company can use the Ferranti machine—and the first step towards their doing so is, I believe, that they should get rid of the Lane-Fox license—the Yorkshire Company shall be sharers of that machine in their district. While matters are *sub judice* between us and the Brush Company it is rather difficult to speak with entire freedom; but your directors know quite well my friendship for the Yorkshire Company. I was in Yorkshire for three days recently, and all the expenses were paid by myself. Whenever I pass to Middlesbrough I use all my influence for the interests of this Company. I was in Middlesbrough yesterday, and what I was distressed to hear of was that difficulty about the Lane-Fox lamp. Up and down the country there was that difficulty, which I look on as no difficulty, when you are working to spread the use of the light. The Hammond Company have said this. Out of the shares we hold, and being by far the largest shareholders in this Company—and we now possess all that we took at £2—we will give so many of them, being by far the most interested parties in the progress of the Company, in order that all these difficulties may be got rid of. Let us suppose Mr. Brown's statement right, and that there is no difficulty as to this Lane-Fox lamp. In that case Mr. Whiteley asks us, "Why do you give away these shares?" Well, what we feel is this, that whoever is right in the matter, the best thing for the Company is to push on its business untrammeled by legal difficulties. A profitable contract has been put before the Leeds authorities by your Company for £11,000. I am perfectly certain on the figures that that order must come to this Company, and if it does not it will be on account of the legal proceedings. The Leeds authorities are talking of giving orders for £50,000 of work gradually, and I feel that the man who gets their first order, and executes it well, will possibly get the whole order. Mr. Ferranti and Mr. Ince, too, were at Leeds the day before yesterday. Mr. Ferranti will be in Leeds next week; and will help in every way to get this first order from the authorities for this Company. That order, however, is liable to go past your Company, because we do not know how we stand as to the Lane-Fox difficulty. Can you not, therefore, understand that we (the Hammond Company), the largest shareholders in your Company, should say that to make our shares more valuable than they are to-day we will sacrifice a certain portion of them? We still have a large portion. We have made this proposal to the Electrical Works Company, so that they might pass it on to you, and the effect of that offer is that we shall settle down to a good business. In spite of the value of the London market, I am more and more convinced of the future of electric lighting. During the past few days I have been away from London, where one's view of the manufacturing interests of this country is somewhat curtailed. During the few days I have been among the manufacturing districts of the north I have seen more and more the boon which electric lighting is going to be to the workpeople of England. I have been, in fact, where people work with gas from four in the morning till twelve at night, and I have been told that as much as 50s. per gaslight has been paid. We can give at this moment a light which does not rob the air of its oxygen, a light of the same or greater brilliancy, just as manageable and one which the workpeople can bring near the thread of their machines without any danger of fire. Mr. Samuel Morley, when he walked with me through Messrs. Copestake's workshops, was astonished at the progress of the incandescent light. As to your Brush patent, the Ferranti machine has been described as better than the Brush, and as practically making the Brush machine obsolete. The great weakness which we, who have been working for the Brush Company in every part of the country have had before us, is the absence of an incandescent machine. We have wanted an incandescent machine of large extent—not one to run 50 or 100 lights. It is of no use to go into a manufactory where there are 5,000 gas jets going, and to say to the proprietor that we have an incandescent machine which will run 80 lights. What we want to be able to offer is a machine which will run 500, 1,000, or 5,000 lights, and under the Ferranti machine that is possible. In all I have said publicly on the Brush machine I have not spoken against it as an arc machine. As an arc machine you are at present using the Brush machine, and you will probably continue to use it. Mr. Ferranti's arc machine may prove as startling in its day as his incandescent machine, but the thing we have before us is the incandescent machine, which does not, for the moment, interfere with the Brush. A day may

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come, however, when that will be obsolete; and the Hammond Company, who have the sole right to use the Ferranti machine throughout Great Britain, are the largest shareholders in your Company. What will be the effect of that? We shall want agents, and in our own interest the Yorkshire Company will have all that the Hammond Company can give it.

Mr. H. W. MAYNARD (a director) then moved a resolution (after expressing his faith in the value of the Brush patent), in effect consenting to transfer to the vendors the Lane Fox license for £30,000 in shares, and £5,000 in cash.

Mr. HASTINGS seconded the motion.

Mr. WHITELEY inquired who would pay the £5,000.

Mr. GUEDALLA replied that the offer was simply before them to be rejected or accepted. It was no use losing time, and he told them distinctly that no modification or alteration would be made in the offer.

Mr. STOBART moved an amendment accepting the offer in the terms proposed.

Mr. INCE seconded it, and alluded to his recent visit to Middlesbrough. From personal observation he spoke in very hopeful terms of the prospects of the Company.

The CHAIRMAN put the amendment, and declared it carried unanimously.

A vote of thanks to the chairman and directors brought the proceedings to a close.

LANCASHIRE MAXIM-WESTON ELECTRIC COMPANY (LIMITED).

The statutory meeting of this Company was held at the offices, 56, New Broad-street, on the 18th inst., Lord Delawarr in the chair.

The CHAIRMAN expressed his satisfaction at having to report that the progress of this Company since its formation and the success which had attended all its lighting operations had been all that could be desired, and with regard to the amount of contracts executed, he was advised that they had exceeded those of any other company within the same period. He had no doubt that the amount of actual and profitable work obtained would continue to increase satisfactorily. He would now call upon Mr. Watt, who had formed the Company, and to whom it owed its present successful position, to give an account of its working and prospects.

Mr. HUGH WATT (managing director), in the course of his observations, said: Before entering upon an account of our operations since the formation of this Company, about the end of October last, as a number of the shareholders of this Company are also largely interested in the parent Company, I wish, with your permission, to enter into one or two matters of interest to both companies with regard to the patents held by the parent company and those conceded to this Company for the districts of Lancashire and North Wales. After referring to the change in the name of the parent company, he observed that they had no occasion to abandon the Lontin and Rapieff systems from any defects in them as arc lights. This course had, however, been taken, owing to the necessity, which shortly became apparent, of possessing an incandescent lamp. With the Maxim lamp and dynamo, and the Weston dynamo and arc lamp, the parent company had become the possessors of three complete electrical systems. Continuing, he said: The two first-named systems being among the earliest patents extant, I may state in passing that, as soon as the statement of claims of certain alleged recent inventions is published, the inventors will have to settle with us, in the first place; and, secondly, should we find these machines generate more electricity, and that they are as durable and less costly than those we are now using, we can make them under our patents. In this case the parent company will have no objection to supply the new machines to the Lancashire Company at a percentage against capital, as by the terms of their agreement they are bound to supply the Weston dynamo and lamps and Maxim dynamo and lamps. I will trouble you with a general reference to the grounds on which we claim special merits for our Weston and Maxim dynamos and lamps. The Weston arc system differs from all other systems, not only in the construction of its machinery, but in the character and extent of its current, and the quality, purity, and steadiness of its light. The Weston arc is shorter than that generally used, and the dynamos are constructed to produce a larger continuous current of electromotive force, which is run at a low speed, and this feature af the system accounts for the fact that no accident has ever taken place in any part of the world from this system, although thousands of lamps are now run in America. Even when a large number of lamps is run on the same circuit, the current necessary is not sufficient to injure any person. Every care is also taken at all times to insure the most complete insulation of all parts as a further precaution. The remarkable steadiness of the Weston arc is due to the shortness of the arc, rendering the effect of impurities in the carbons less noticeable than in the long arcs, and further rendering the light a truer sunlight, and more free from bluish or violet tints. The Weston dynamo gives the largest per-centage of electricity, the loss being only about 10 per cent., and the 10-light machine produces rather over 15,000 candle-power, making it, at the price at which it is sold, the cheapest machine in the market. I will now refer shortly to the Maxim system. The incandescent system for private lighting is the most wonderful and perfect yet introduced. Unless on the grounds of economy this system, consisting of a slender carbon conductor burned in vacuum, is superior to the voltaic arc as an absolutely steady and uniform light, and capable of indefinite distribution. Professor Weston has just perfected a shunt-wound Weston, self-regulating and specially wound to suit the Maxim lamps, whereby only the quantity of current necessary for the lamps you choose to burn is generated, thus effecting a great saving in steam-power for the purpose of domestic lighting, where the lights required will necessarily vary as much as from, say, 1,000 to 5,000. This machine acts instantly and spontaneously, so that the light in the lamps left burning does not vary. This is at present the only machine in use which can accomplish this most desirable result. Where it is desirable to vary the illuminating power of the lamps, a regulator can be introduced for this purpose. The Maxim carbon, in the shape of the letter M, thus presenting a fuller and more uniform body of light than any other, is remarkable for its durability and capacity to withstand powerful currents. These lamps have been known to last 3,000 hours, and have been run up to 600 candle-power, which is far in excess of the capabilities of any other incandescent lamp. But our inventors have not been satisfied even with these superlative attainments, and the parent company have just patented an incandescent carbon, which is destined, we think, to supersede our present carbon, being absolutely indestructible. The difficulty to be overcome with regard to an incandescent carbon is chiefly to retain sufficient delicacy and evenness of structure with the highest possible resistance, and in the case of this lamp 3 4,000 ohms resistance has been attained, without the necessity for subsequent treatment. The Maxim and Weston systems, with their ordinary dynamos, regulators, indicators, self-exciting and shunt-wound machines, cut-off boxes, time meters, switches, fusible plugs, single and duplex Weston and Maxim incandescent lamps of various sizes, as well as all future inventions by this eminent electrician for some years to come, is in a position to deal efficiently and economically with public and domestic lighting under every phase and condition. As to the operations of the Lancashire, it is now fully two months since this Company, having been fairly floated, was in a position to undertake lighting. Our centre, in Peter's-lane, Liverpool, had been partly developed by the parent company, and a number of contracts secured, and a second centre taken and some plant put down. In a very few weeks, owing to the success of the lights, we were simply inundated with applications for the light, when, unfortunately, the Corporation stepped in and compelled us to suspend our further operations. The Liverpool council decided to apply to the Board of Trade for a provisional order to supply electric light, but having since rescinded this resolution, and determined to postpone any action in the matter for a year, I was in hopes, as we were the only electric Company who had lit there for any length of time satisfactorily—we have now run several places for a year—that they would grant us a license to execute the contracts offered, but they have not yet seen fit to do so. Had we been allowed to go on, we should now be supplying about 500,000 candle-power of light, at a rental of several thousands per annum, which would have shown a handsome return on the capital employed. The Company has been fortunate in securing as manager Mr. E. H. Thomson, a gentleman of thirty years' electrical experience, and who has been successful in every installation he has fitted up. In Manchester and district we have lit several establishments and mills, and have been in negotiation to lay down a centre similar to that in Peter's-lane, Liverpool. We have also been in treaty, and shown our lights at different places in Lancashire and Wales, and all with best possible results, and are now in negotiation for the sale of a large number of installations. We have not overlooked the lighting of steamers and mines, and are in treaty with all the leading steamship and mine owners.

Mr. WHITWORTH (director) gave an account of operations in Manchester and district, which had been placed under his direct control.

Mr. E. H. THOMSON entered into details as to what had been done since the Company was formed.

Admiral INGLEFIELD (director), in reply to Mr. Brown, said, that having given much attention to the storing of electricity, he was of opinion that accumulators would only become of use in exceptional circumstances, and that the bulk of lighting would continue, as at present, to be done by means of direct supply from convenient centres, as the most economic mode. The parent company, however, had the refusal of one of the latest accumulators, which was considered to be as good as any yet invented.

The meeting closed with a vote of thanks to the chairman and the board.

THE RAILWAY AND ELECTRIC APPLIANCES COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on the 24th inst., at the Cannon-street Hotel, the Duke of Manchester in the chair, "to consider the propriety of approving and, if deemed desirable, to pass a resolution approving and sanctioning a conditional contract, proposed to be dated the 4th day of January, 1883, and to be made between the Company and Messrs. L. Clark, Muirhead, and Co., for the acquisition of their works and premises, situate at Millwall and at Regency-street, Westminster; and of their business, goodwill, plant, and stock-in-trade, upon the terms and subject to the conditions contained in such conditional contract."

Mr. WILLIAM SKINNER (the secretary) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, the object of this meeting is to ask you to sanction—in fact we hoped to be able to ask you to confirm and sanction—an agreement with Messrs. Latimer Clark, Muirhead, and Co., but I am sorry to say that the negotiations have not been completed as to details, and therefore we cannot put before you a definite agreement for your sanction and approval, but what we can state to you I hope will be eminently satisfactory to you. The general grounds upon which we are negotiating you no doubt know. Messrs. Latimer Clark and Company have a great reputation as manufacturers of electric and telegraph appliances, and their names are also well known in scientific circles. On that question I think you can have no doubt whatever. We have a note this morning showing the amount of business they are doing. They have lately put out contracts to the amount of £100,000, and I have no doubt if they get the contracts they will derive a very large profit. They have orders now in hand to the amount of £20,000 or £30,000, and this morning they have had an inquiry for a matter of very considerable amount—some £25,000 of electric and telegraph business—so that we should be, if we joined them, stepping into a very important business. I should state that they have works in Regency-street, Westminster, which I have visited, and they seem to be doing very excellent work. They have acquired very extensive premises at Millwall, where they propose to erect very extensive works. In fact, it would be necessary to have very extensive works to carry out all the business they are anticipating. With regard to the heads of agreement, I had, perhaps, better divide them into two—one, the absolute premises, plant, and stock we take over; and the other, the goodwill of the business. Now, with regard to the premises, plant, and stock, Mr. Worley has investigated the value which we will agree to take them at. We are not bound to take them unless we agree upon the value, and we shall certainly not agree to that unless we see it is to the interest of the Company to make the bargain. All the sum that we pay for that will be a first charge on the profits of the business to the extent of 7 per cent. It is proposed to pay cash for the stock, and to pay a rent for the

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premises and plant. I believe it is to be paid by quarterly instalments during two years. We shall receive 7 per cent. on all the capital we spend in that way before there is any division between Messrs. Clark and Muirhead and this Company. In payment of the goodwill of their business, we are to give them £10,000 in fully paid-up shares, and two-fifths of the net profits of the business, this Company having the other three-fifths, that is, we get 60 per cent. of the net profits after having withdrawn for ourselves the 7 per cent. In short, we get 60 per cent. of the balance, and Messrs. Clark and Muirhead get 40 per cent. I should say in consequence of our not having definitely settled the agreement we must ask you for discretionary powers to agree to or to modify this agreement, as we see fit. If you have confidence in us as directors I am sure you will consider yourselves safe in our hands. It is as much our interest as yours that we should make a good bargain, and you may depend that if you give us this discretion we shall endeavour to exercise it in the interest of the Company.

Mr. VALLANCE (the solicitor) then read the agreement.

Mr. EDMESTON thought the shareholders should have more information before taking over all the liabilities on Messrs. Clark and Company's contracts, and that they should know what they had done in the past. This Company was established to buy a business for the enormous sum of £95,000, and it had been proved not to be worth a third of the sum. Before taking another business he thought the chairman should tell them something of the success they had already attained. Electric lighting was in that transition state that it might be a very good thing for Messrs. Clark and Co. to get rid of machinery which might have become obsolete.

The CHAIRMAN replied that those were just the matters in question between themselves and Messrs. Latimer Clark and Co., and matters which Mr. Worley was investigating, and which they hoped would have been settled and arranged before this meeting. Mr. Worley had not been able to make out definitely what profits the firm had been earning, because their accounts had not been made up to the 31st December. They had now been made up, and Mr. Worley hoped in a few days to be able to make out what the profits had been, but he was pretty well satisfied that they had been considerable. With regard to the plant and material, that was a matter in discussion between Mr. Worley and Messrs. Latimer Clark and Co. In reference to the contracts, Messrs. Clark and Co. were under an engagement with an Australian Brush Lighting Co., under which they were bound, if necessary, to put up works in Australia. The directors thought that a very uncertain obligation, and, therefore, declined to take over the contract. The other contracts to which allusion had been made were merely orders to furnish manufactured goods, and when they were furnished there was an end to the contract. The goods would be furnished by contract, and the order would not be taken unless there was a good profit, and when those goods were furnished, and the payments made, there was an end to the obligation. Previous to joining the Company, he made inquiries and satisfied himself that everything was satisfactory.

In reply to questions by Colonel JACKSON,

Mr. WORLEY said that all the contracts had been submitted to him, and he could not find anything in them that was at all objectionable. They did not involve, so far as Latimer Clark and Co. were concerned, any liability of a serious character, and the obligations seemed to be, so far as he could see, all on the other side; that was to say that certain persons had undertaken to give them the option of supplying the electrical machinery and apparatus that they required on certain defined terms, and they were to pay for that on delivery, and when delivery was made there was an end of the liability, and under those contracts it seemed to him that the benefit was all on the part of Messrs. Clark and Company. He could not discover in them any liabilities whatever of an extraordinary character. As to the capital required it would be from £20,000 to £30,000. £30,000 would represent the stock, machinery, plant, and working capital, assuming the Company carried on the business on much about the same lines as the vendors had done; but, if the business materially increased, £30,000 would be insufficient. He expected that, in the course of ten days or a fortnight, he should be able to make a definite report as to the profits. With regard to the machinery and plant, the directors had agreed with him that it would be a great mistake to take the whole thing bodily at a valuation. That would mean an unknown quantity, and if there were certain machines which were antiquated they would feel justified in not accepting them. The general basis would be, assuming the machinery to be of the right kind, to take it at actual cost, but if it were old to make a liberal allowance for depreciation. In going into this matter they would not base their calculations upon one balance-sheet but on several.

Mr. SMITH said they had been fortunate in obtaining orders for a considerable amount of work by way of trials from the National Telephone Company for telephone purposes, and only last week he received from the manager of that company the most flattering assurance that, of all the apparatus of the kind he had received up to now, he had received none that worked better than that turned out by this Company. He believed that they would do a large business in furnishing electrical lighting apparatus, and would be able to compete successfully with the Americans, who had hitherto had the monopoly of that business. They had very good friends in one of the railway companies in Scotland, from whom they anticipated receiving orders. They had husbanded well the resources of the Company, and he believed that when the balance-sheet was submitted, the shareholders would be satisfied.

A resolution was then passed giving the directors discretionary power to enter into the proposed arrangement, after which a vote of thanks to the chairman and directors terminated the proceedings.

THE DUBLIN ELECTRIC LIGHT COMPANY.

An extraordinary general meeting of the shareholders of the Dublin Electric Light Company (Limited) was held at the offices of the Company, 37, College green, at twelve o'clock on Monday, the 22nd inst. Mr. Thomas Revington, J.P., chairman of the Company, presided. The following special resolutions, adopted at the meeting of the 4th inst., were unanimously confirmed:—1. "That the Company be wound up voluntarily." 2. "That Robert Gardner, 40 and 41, Dame-street, Dublin, public accountant, be, and he is hereby, appointed liquidator, for the purpose of such winding-up."

CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

Report of the directors for the half year ending 31st December, 1882, to be presented at the twenty-third ordinary general meeting of shareholders to be held on the 31st day of January, 1883:—The directors beg to submit, duly audited, the balance-sheet and accounts for the half year ended 31st December last. It will be seen from these that the gross receipts, including the balance brought from last account, amount to £17,012 6s. 8d., and the gross expenditure, including the half of the annual payment for the new cable, to £6,012 9s. 7d., leaving a sum of £10,999 17s. 1d. to the credit of revenue account. After placing £1,325 to the reserve fund, increasing that fund to £49,500, and providing for the dividend on the preference shares, a balance of £6,674 17s. 1d. remains, out of which the directors recommend the payment of a dividend on the ordinary shares at the rate of 7 per cent. per annum, free of income tax, leaving the sum of £1,074 17s. 1d. to be carried forward to the current half year's account. The cables have continued in good working order, but Mr. Keith, the company's engineer, reports a small fault in the 1875 Cienfuegos-Santiago one, which he recommends should be cut out. An early opportunity will be taken for doing this, the cost of which, it is estimated, will not be great, the fault being near Cienfuegos in shallow water. The Central and South American Company's cables having been completed and opened for traffic, they are now competing with this and the West India Company's lines for Colon and Panama business. A reduction has been made in the tariffs to meet the competition. The directors regret to state that their esteemed colleague, Mr. Thomas Hughes, Q.C., who has been chairman from the formation of the Company, has been compelled to resign his seat at the Board in consequence of his appointment to a County Court judgeship. It has been decided for the present not to fill up the vacancy. The usual comparative statement of traffic is submitted herewith.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES JAN. 24.		BUSINESS DONE WEEK ENDING JAN. 24. Highest.	Lowest.
Anglo-American	50,	51	50⅞	50
Do. Preferred	81½,	82½	82½	82
Do. Deferred	18½,	19½	19½	18⅞
Brazil Submarine	11⅞,	12⅛	12⅛	12
Cuba	10,	10⅛	10⅛	10
Do. Preference	17,	18	—	—
Direct Spanish	6⅞,	6⅞	6⅞	6⅞
Do. Preference	16,	17	16½	16½
Direct United States Cable	12,	12½	12½	12½
Eastern Telegraph	10⅞,	11⅛	11⅛	10 15-16
Do. 6 per Cent. Preference	13½,	13⅝	13⅝	13⅜
Do. 5 per Cent. Debentures, 1899	105,	108	—	—
Eastern Extension	11⅞,	12⅛	12 1-16	11 15-16
German Union	10⅛,	10⅜	—	—
Globe Telegraph and Trust Company.	6⅞,	⅞	6⅞	6 7-16
Do. Preference	12⅝,	12⅞	12 13-16	12 11-16
Great Northern	12,	12⅛	12⅛	12
Indo-European	32,	33	—	—
Mediterranean Extension	1½,	2	—	—
Do. Preference	6,	8	—	—
Reuter's	11½,	12	—	—
Submarine	252,	257	255	255
West India and Panama	1⅛,	1⅛	—	—
Do. 1st Preference	7,	7⅛	7	7
Western Brazilian	7⅛,	7⅞	7⅞	7⅞
West. Union 7 per Cent. 1st Mortgage	122,	126	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅝,	¾	¾	11-16
Oriental	½,	⅝	13-16	11-16
United Telephone	10½,	11	11⅛	10⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	5⅛,	6⅛	6 7-16	5⅞
Do. (fully paid)	10,	11	11⅛	10⅛
Hammond Light	2¾,	3¼	3	2⅞
Eastern Electric (£4 pd)	1,	1⅛	1⅛	1
Pilsen, Joel, and General Electric	¼,	⅜	⅝	½
Swan	2⅛,	2⅜	2⅛	2 5-16
Maxim-Weston	¼,	¼	⅜	⅜

TRAFFIC RECEIPTS FOR DECEMBER, 1882.

COMPANIES.	Dec., 1882.	Dec., 1881.	Increse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	2,741		—
Direct Spanish Telegraph Company	1,316	1,458	—	112
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	49,610	49,844	—	234
Great Northern Telegraph Company	17,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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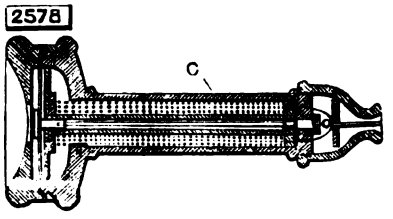
RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

2578. IMPROVEMENTS IN TELEPHONIC INSTRUMENTS, *S. P. Thompson, Bristol.*—31*st May*, 1882. 6*d*.

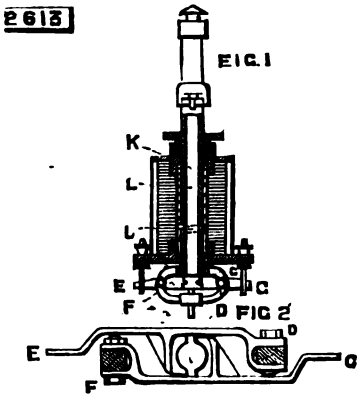
This invention relates to improvements in the receiver of Phillip Reis. One form of the inventor's improvements is shown in the accompanying figure. The action of the instrument illustrated is as follows:—If the current received in the coils C through the line from the transmitter increases in strength, it will change the molecular



condition of the central rod or wire, causing it to elongate slightly if of iron, steel, or cobalt, and if it be nickel, to contract slightly. A decrease in the strength of the current will be followed by a partial demagnetisation of the central rod, producing an inverse movement. Hence, as one end of the rod is tightly screwed up to the case of the instrument, and the other affixed to the tympanum, the varying or fluctuating currents entering the same will cause corresponding vibrations of the tympanum. Other improvements are also described and illustrated.

2613. IMPROVEMENTS IN ELECTRIC LAMPS, *W. E. Ayrton and J. Perry, London.*—3*rd June*, 1882. 6*d*.

This relates to arc lamps. The upper carbon-holder passes through an electro-magnet (see the figure herewith) and carries a frame, C C, with hinges, D F, and levers, D E F G. These levers pass round and clutch the holder. The tube, partly of brass and partly iron, frame, and levers carrying the carbon-holder are hung by spiral springs, J K, from the framing, and in the normal condition of the lamp, when the arc has



been formed, the downward suction of the tube, together with the weight of the movable parts, just balance the upward pull of the springs. The electro-magnet is wound with a coil of considerable resistance, which acts as a shunt to the arc. When the latter gets too long and its resistance increases, more current passes through the magnet, and the carbon falls, thus shortening the arc. It cannot fall far before the two levers come in contact with stops at E and G. This diminishes their grip, and lets the carbon slide independently of the tube and frame C. This is the feeding arrangement. Fig. 2 gives a more detailed view of the gripping levers.

2659. IMPROVEMENTS IN PRIMARY AND SECONDARY BATTERIES, &c., *W. Brain, Cinderford, Gloucestershire.*—6*th June*, 1882. —(*Void.*) 2*d*.

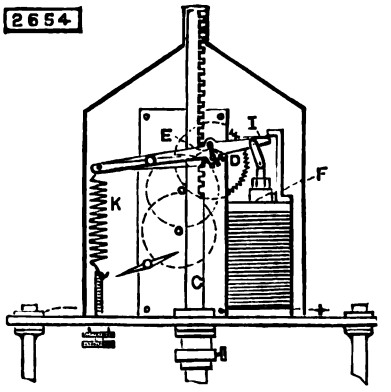
This relates to improvements on the inventor's patent of 30th March, 1882, and consists mainly in subjecting the electrodes and secondary batteries therein described to considerable pressure before or after charging.

2760. POSTS OR SUPPORTS FOR TELEGRAPH WIRES, &c., *H. H. Lake, London.*—12*th June*, 1882.—(*A communication from J. G. Richard, Paris.*)—(*Not proceeded with.*) 2*d*.

This relates to the means of preservation, and it consists in isolating the foot or base of the post from the ground and destructive elements by enclosing the part of the said post which is susceptible of being attached by the humidity of the earth in an impermeable box, cylinder, base, or block.

2654. AN IMPROVED ELECTRIC LAMP, *R. J. Hatton, Stratford, and A. L. Paul, Kensington.*—6*th June*, 1882. 6*d*.

The action of the inventor's lamp will be understood on reference to the accompanying illustration. When the current is switched on, plunger F is drawn into the solenoids, drawing down one end of lever E, and causing spring pawl



I to engage and give motion to ratchet wheel, D, which motion is transmitted to rack, C, and the upper carbon is lifted so as to form the arc. When the arc becomes too long the action of the solenoid is weakened and spring K overcomes it, disengages I, and the carbon descends until the arc is adjusted to the proper length.

2762. IMPROVEMENTS IN VOLTAIC BATTERIES, *D. G. FitzGerald, Brixton.*—12*th June*, 1882. —(*Not proceeded with.*) 2*d*.

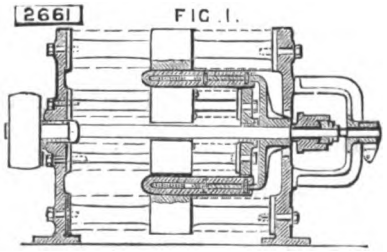
This relates to the employment of peroxide of lead in a strongly compressed condition as the depolarising agent in primary batteries. The positive element may be tin or other metal in a more or less porous condition, and the negative element carbon.

2763. MANUFACTURE OF PEROXIDE OF LEAD, &c. *D. FitzGerald, Brixton.*—12*th June*, 1882.—(*Not proceeded with.*) 2*d*.

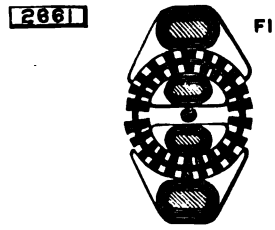
According to one portion of the invention the inventor treats certain salts and insoluble compounds of lead in admixture with an electrolyte, which may be a salt of a metal other than lead, by subjecting them to electrolysis in a tank or in a series of tanks containing suitable electrodes.

2661. IMPROVEMENTS IN APPARATUS FOR PRODUCING ELECTRIC CURRENTS AND IN APPARATUS FOR MEASURING SUCH CURRENTS, *Professor J. Blyth, Glasgow, and D. B. Peebles, Bonnington, Edinburgh.*—7*th June*, 1882. 6*d*.

For the production of currents the inventors employ the machine illustrated in Figs. 1 and 2, which are longitudinal and transverse vertical sections respectively. The machine has a rotating armature consisting of a cylindrical ring of soft iron, having upon it a number of separate coils of insulated wires. Between the coils are iron links, by means of which the armature ring



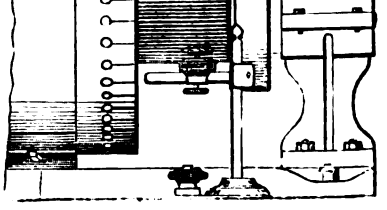
is fixed to one end or edges of a cylinder of iron, which has at its other end a disc or spokes connecting it to a boss fast on the driving shaft. The coils of wire are connected to a commutator. Separate electro-magnetic pole pieces are arranged to act upon the outer and inner sides of the armature ring, and the magnet shanks or bodies of the external pole pieces are excited by coils of insulated wire, which are separate and distinct from similar coils employed to excite the magnet shanks or bodies of the internal pole pieces. Thus a double machine is formed, as currents can be produced with either internal or external



electro-magnets removed. For measuring a current the inventors take a shunt of comparatively great and known resistance from the main circuit by means of two wires which are led to separate electrodes immersed in water in a closed vessel. The shunt current causes electrolysis of the water, and the oxygen or hydrogen, or the two combined, are led through a meter such as is used for measuring illuminating gas. As the production of the gases has a known and definite relation to the current passing through the main circuit, the meter measurement serves as a data for calculating the quantities of the main current.

268,956. DYNAMO-ELECTRIC MACHINE, *Elmer A. Sperry, Cortland, N.Y.*—*Filed* 28*th April*, 1881.

Claim.—(1) In a dynamo-electric machine, a commutator mounted loosely on the armature shaft, its sections retaining their connections with their respective armature coils, in combination with means for automatically adjusting said commutator, as specified. (2) In a dynamo-electric machine, the combination of the flexible conductors with the sections of an adjustable commutator, whereby the electric connections of the sections are retained in all positions, and means, as described, for automatically adjusting the position of said commutator as specified. (3) In a dynamo-electric machine, the centrifugal governor, as described, in combination with the movable commutator and connected with the same, whereby its position is automatically controlled in



response to variations in the speed of rotation of the machine, substantially as specified. (4) The combination, with the movable commutator of a dynamo-electric machine, of a current regulating device, substantially as described, whereby the commutator is caused to move automatically on the shaft, relative to its points of maximum and minimum current, in response to variations in an electric current, substantially as described. (5) In a dynamo-electric machine, the combination with the commutator brush clamps of the supporting springs attached thereto, the free ends of which rest in slots provided in rods, upon which the clamps are loosely mounted, whereby the pressure of the brushes can be adjusted by rotating said rods, substantially as described. (6) In a current-regulating device, the combination of the pawls, links, lever, armature, and spring, with ratchets, substantially as specified.

2740. IMPROVEMENTS IN ELECTRIC LAMPS, &c., *G. Zanni, Hatton-garden.*—10*th June*, 1882.—(*Not proceeded with.*) 2*d*.

This relates to improvements in lamps in which light is produced by the incandescence of a carbon point which is pressed by weight against a block of carbon. Two or more carbon rods are proposed to be substituted for the one hitherto employed, in order to avoid the extinguishing of the light owing to flaws in the single carbon.

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SLIP

NEW COMPANY.—The Canadian Electric Light Company has been formed at Montreal.

TELEGRAPH EXTENSION.—The telegraph is to be extended to the village of Hopeman in Elgin county, Scotland.

ROYAL INSTITUTION.—Yesterday (Friday) evening Sir Wm. Thomson, F.R.S., was to lecture on "The Size of Atoms."

Dr. SIEMENS.—The St. Petersburg Academy of Sciences has elected Dr. C. W. Siemens, F.R.S., a corresponding member.

BRITISH INSULITE COMPANY.—A meeting of this company is to be held on Monday next, at the Guildhall Tavern, at 2:30 p.m.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended January 26 amounted to £4,043.

PROF. HELMHOLTZ.—A telegram from Berlin, dated Jan. 30, says that the Emperor has ennobled the celebrated scientist, Professor Helmholtz.

TRANSMISSION OF POWER BY ELECTRICITY.—The first of a series of articles on this subject by Professor O. J. Lodge appeared in last week's *Engineer*.

THE TELEPHONE IN BOMBAY.—The Bombay Telephone Company held its first annual meeting on January 8. There are now 147 subscribers to the exchange.

ELECTRIC LIGHTING IN BRISBANE (QUEENSLAND).—Latest accounts from the colonies say that a very successful trial of the electric light has been made in Brisbane.

ELECTRIC LIGHTING AT STOCKPORT.—The electric light was used for the first time in the police court at Stockport last week. The Pilsen arc lamp was employed.

EASTERN EXTENSION TELEGRAPH COMPANY.—This company notify that the coupons on their Six per Cent. Debentures, due on Feb. 1, will be paid at the Consolidated Bank.

ELECTRIC LIGHTING AT BATH.—The Great Western Electric Light Company have obtained a contract for lighting the extensive premises of the "Merchants' Alliance," 19, Stall-street, Bath.

PROPOSED TELEPHONIC EXCHANGE FOR ABERDEEN.—A scheme is on foot in Aberdeen to start a telephone exchange, which shall work on a cheaper basis than that of the National Telephone Company.

ST. MARYLEBONE.—The Vestry of St. Marylebone intend to oppose provisional orders, but will ask for leave to negotiate with companies for supplying electricity for a limited period under license, in a selected portion of the parish.

RESIGNATIONS.—Sir Charles Bright and Mr. Edward Bright have resigned the positions they have held with the British Electric Light Company, the former as consulting engineer, the latter as a member of the board of directors.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending January 26, 1883, were £2,728, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

GREENWICH.—The Greenwich Board of Works have resolved to write to the Board of Trade stating that they are favourable to the supply of electric light in part of their district, but are opposed to any scheme which proposes to absorb the whole of the district.

SOUTH AFRICAN TELEGRAPHS.—The revenue receipts of Cape Colony from telegraphs during November last were £4,310 4s. 4d., against £5,476 18s. 11d. in the same month of 1881, or a decrease of £1,166 14s. 7d., mainly owing to a reduction in the tariff rates.

ELECTRIC LIGHT FOR SHIPS.—In the Austrian Parliament, at Vienna, on the 26th of January, Herr Rosier addressed an interpellation to the Minister of Commerce in favour of the use of the electric light on railways and ships with a view to the prevention of accidents.

GREAT NORTHERN TELEGRAPH COMPANY.—This company announce the issue of £300,000 five per cent. debentures, with half-yearly coupons attached, payable 1st March and 1st September in each year. Messrs. C. I. Hambro and Son offer the debentures for subscription at £101 for each £100.

THE ROYAL SOCIETY.—At the meeting of this society on Thursday the following papers were to be read, viz.:—Mr. S. Bidwell "On the Electrical Resistance of Carbon Contacts," and Professor D. E. Hughes, F.R.S., "On a Theory of Magnetism, Based upon new Experimental Researches—Preliminary Note."

ELECTRIC LIGHTING FOR WORKSHOPS.—Last week Mr. Andrew Jamieson read a paper before the Institution of Engineers and Shipbuilders at Glasgow on "Electric Lighting for Large Spaces and Workshops." We have no space to refer at length to this paper in our present issue, but shall hope to do so later on.

CHELSEA.—At the last meeting of the Chelsea Vestry the report of the Electric Lighting Committee, which we gave in last week's issue, was adopted, and votes of thanks to Mr. Mossop, chairman, and Mr. G. H. Stayton, surveyor, for their services in connection with the drawing up of the report were unanimously passed.

THE TELEPHONE CASE.—The case of the United Telephone Company *v.* Harrison, Cox-Walker, and Co., had progressed so far during the week that Mr. Aston, Q.C., counsel for the respondents, had commenced his argument on Tuesday last. Up to the time of going to press, however, the result of the case was still unknown.

THE "TARTAR."—The steamship "Tartar" was launched last week at Whiteinch. She has been built for the Union Steamship Company, by Messrs. Aitken and Mansel. Her dimensions are:—Length 392ft., breadth 47ft., depth 33ft. 6in., gross tonnage 4,359. She is magnificently fitted up, and will be lighted by incandescent lamps.

ELECTRIC LIGHTING IN KENTUCKY.—The Brush Company has challenged the United States Electric Light Company to a public test of their systems, in Louisville, Kentucky. The loser, says the *Sanitary Engineer*, is to pay 1,000dols. towards the expenses of the exhibition, and 4,000dols. to the Polytechnic Society of Kentucky.

FIRE ALARMS IN GLASGOW.—The electric street fire alarums placed throughout this city were used 152 times to intimate the outbreak of fires during last year, and in 45 instances were the means of calling out the brigade unnecessarily—15 of which alarms were given with good intent, nine through contact with other wires, and 21 thoughtlessly or mischievously.

PROGRESS.—Five large steamers were last year fitted with electric lights by one of Messrs. Siemens's agents at Manchester. They were—the "Normandie," 400 Swan lamps,

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and 16 Siemens arc lamps; the "Arizona," 300 Swan lamps; the "Antonio Lopez," 70 Swan lamps; the "Orient," 160 Swan lamps, and 4 arc lamps; and the "Austral," 170 incandescent, and 4 arc lamps.

THUNDERSTORM.—During a thunderstorm in the neighbourhood of Pontypridd on Tuesday, a house, occupied by a tenant-farmer named Evan Williams, was struck three times by the lightning. One flash passed down the chimney stack and knocked down a mantelpiece, another knocked away a portion of the building, and, passing into an outhouse, killed five cows, and a third smashed the bed room window.

FOG SIGNALLING AT SEA.—Mr. W. Langdon, superintendent of the Telegraph Department of the Midland Railway, writes to *The Times*, recommending that steamers, when caught in a fog at sea, should indicate their course to approaching vessels by a system of whistling, based on the Morse alphabet, as used by telegraphists; and he further suggests that this might be done by means of machinery.

PHŒNIX ELECTRIC LIGHT COMPANY.—The *Gazette* of January 26 contains a notice to the effect "that at an extraordinary general meeting of the members of this company at the Cannon Street Hotel, E.C., on the 5th January, the following special resolution was duly passed; and at a subsequent extraordinary general meeting on the 23rd January the following special resolution was duly confirmed:—'That the company be wound up voluntarily.'"

THE TELEPHONE IN INDIA.—At the request of H.E. the Commander-in-Chief, instructions have been issued for putting up, before the next season, telephonic communication between Sir Frederick's usual residence, "Snowdon," at Ootacamund, and the office of the head-quarters, and any other Government departments he may consider necessary, the necessary "exchange" station being the Government Post Office. So says a contemporary.

THE "HAMMONIA."—On Saturday last this vessel, which has been recently built by Messrs. J. and G. Thomson, of Clydebank, Glasgow, for the Hamburg-American Steamship Company, went down the Firth on her trial trip. She is 375ft. long, 45ft. wide, and 34ft. deep. Her gross tonnage is about 5,000. She is fitted with 100 Swan lamps, the current for which is supplied by a Siemens dynamo, driven by a 6 h.-p. (nominal) Tangye engine.

ELECTRIC LIGHTING PLANT FOR TRANSPORT.—An electric lighting plant for a cotton mill in one of the smaller American republics has just been supplied by Messrs. Siemens Brothers to a Manchester firm. It comprises seven arc lamps, 236 Swan incandescent lamps, one dynamo-machine (SD^0) and one alternate current machine (W^2). The whole has been so arranged that it can be put together on the spot by persons without knowledge of electrical apparatus.

SOCIETY OF ARTS.—The following premium is offered by the Society of Arts for the 129th session of the society (1882-3):—Howard Prize: A prize of £100, for the best essay on the Utilisation of Electricity for Motive Power. Preference is to be given to that essay which, besides setting forth the theory of the subject, contains records, with detailed results, of actual working or experiment. The society reserves the right of publishing the prize essay.

METROPOLITAN BOARD OF WORKS.—At the last meeting of this Board Mr. Selway moved "That it be referred to the committee (Works and General Purposes Committee) to prepare and deliver to the Board of Trade objections to the various provisional orders applied for under the Electric Lighting Act, 1882, with such clauses as may secure the Board's right over the Thames Embankments, the bridges, subways, and the sewers of the metropolis," which was adopted.

M. GASTON PLANTE.—This well-known French electrician (the inventor of the secondary battery) has been presented by the Society of Arts of Paris with the Ampère medal for economic arts. We are glad to be able to chronicle this addition to the honours conferred on a man like M. Planté, whose modesty is so great that one rarely sees his name mentioned except by those who remember that the secondary battery of to-day is Gaston Planté's own child in slightly altered garb.

THE TELEPHONE IN CANADA.—The use of the telephone has developed largely in Canada. In 1882 more than 1,000 miles of telephone lines were constructed. Montreal has 866 subscribers, Toronto 525, Ottawa 250, and Quebec 240. Besides these larger centres more than 100 small towns have exchanges, and some of them are connected to one another by telephone lines. The total number of subscribers in the Dominion is about 4,500.—*Bulletin* de la Compagnie Internationale des Telephones.

WIRES IN PHILADELPHIA.—According to an American contemporary, Philadelphia derives an annual revenue of 12,000dols., from telegraph, telephone, and electric light companies, for the use of its overhead and underground wires. Each company makes a return annually of the number of poles, &c., and a payment of 5dols. per annum for each mile of wire used for telegraph or telephone purposes, and 15dols. per mile per annum for electric lighting purposes is required. There are at present about 10,000 miles of wire in the city.

STANDARD WIRE GAUGE.—At a recent meeting of the Wolverhampton Chamber of Commerce it was reported that the council had written to the Board of Trade saying that though the standard wire gauge proposed by that Department was not in every respect such as they would have liked, yet they felt it would fulfil the purposes of a national standard wire gauge. They were so anxious to see a workable gauge introduced that they preferred not to make any suggestions lest they should hinder, or possibly frustrate its adoption.

SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.—The next meeting of this society will be held at 25, Great George-street, on Thursday, February 8, at 8 p.m., when the following papers will be read:—"On the Magnetic Storm of November 17th, 1882," by James Graves, member (communicated by H. Weaver, member); "On a Magnetic Storm in India," by E. O. Walker, member; "On Earth Currents in India," by E. O. Walker, member; "Earth Currents (third paper), Sun Spots, and Electric Storms," by Alex. J. S. Adams, associate.

ELECTRIC COMMUNICATION IN TRAINS.—Sir Edward Watkin's somewhat loose and illogical statement at a recent meeting of the South Eastern Railway Company that, though the company had its trains fitted with electric communicators between passengers and guard, these had not been used once in six months, and, therefore, they were useless and needless, has been severely and rightly criticised by correspondents of the *Daily News*. Their argument is "prevention is better than cure," and that the fact that the communicators had not been used showed how effectual they were.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—An extraordinary general meeting of this company will be held at the offices, 38, Old Broad-street, E.C., on the 6th February, at one p.m., for the purpose of considering and, if thought fit, passing a special resolution approving the Bill now pending in Parliament, intituled "A Bill for re-

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moving doubts as to and for extending the powers of the Telegraph Construction and Maintenance Company (Limited)," and for other purposes. The principal object of the Bill is to enable the company to carry on the business of constructing and dealing with works and apparatus for electric lighting and other uses to which electricity can be applied.

ANGLO-AMERICAN TELEGRAPH COMPANY.—At a meeting of the board of directors of this company held on the 26th January it was resolved (after placing £37,500 to the credit of the renewal fund for the quarter ending 31st December, 1882) to recommend to the proprietors at the next half-yearly general meeting of the company to be held on the 9th February the declaration of the following dividends, all free of income tax:—(1) A balance dividend of 1 per cent. upon the ordinary consolidated stock for the year ending 31st December, 1882; (2) a balance dividend of 2 per cent. upon the preferred stock for the year ending 31st December, 1882, both payable on 10th February. After paying the foregoing dividends, there will be a balance of about £6,900 to be carried forward to the next account. The above dividends, together with those already paid, will amount to $2\frac{3}{4}$ per cent. on the ordinary consolidated stock and $5\frac{1}{2}$ per cent. on the preferred stock for the year 1882.

ELECTRIC LIGHTING IN ST. MARTIN'S-IN-THE-FIELDS.—The Vestry of St. Martin's-in-the-Fields will oppose all the provisional orders referring to their district on the following grounds:—"That they seek to set aside the provisions of the Electric Lighting Act of 1882, and the rules of the Board of Trade in relation thereto, and to extinguish the right to control the public streets now vested in the local authority; that there is no provision for a regular and efficient supply of electricity, nor for the security of the public against personal injury, inspection by the local authority, or for a reduction in price after the payment of a dividend of, say, 10 per cent; that the companies seek, without obtaining consent of the vestry, power to break up the public streets, to place wires above ground, and to acquire sites for lighting stations." The vestry also consider that no concession to a company should be for more than fourteen years, that the vestry should have power to inspect the company's accounts, and that penalties should be exacted for failure to execute the proposed works within a reasonable time.

THE ANGLO-AMERICAN BRUSH CORPORATION.—We have received a copy of a circular that has been issued by this company, which briefly recapitulates the events which took place at the meeting, reported in our last issue. After reiterating what was then said by the chairman, viz., that they could not accede to the proposition to appoint a committee of shareholders to examine and report on the books and affairs of the corporation, since the report would necessarily be made public, and would injure the corporation by revealing its trade secrets, the circular states, in answer to "allegations freely made at the meeting" above-mentioned, that "the directors have during the past six months been earnestly engaged in, and have now perfected, the manufacture of a new class of economical machines for incandescent lighting, and of apparatus of various descriptions essential to the success of domestic and general electric lighting." The directors conclude by stating that there is a a vacancy at the Board which they will be glad to fill up "if suitable names are suggested to them." We would refer our readers for further information to our reports of meetings.

ELECTRIC LIGHTING IN BERLIN.—A correspondent sends us an account of the lighting of the Berlin Academy of Painting and Sculpture as carried out by the Edison Company. The entrance from the street was lighted by ten lamps fitted on to two lampposts and a chandelier in the form of an imperial crown. The vestibule and stairs were lighted by another chandelier with 32 lamps and two large wall brackets. This is, we believe, the first time that an exhibition of pictures has been opened at night time in Berlin. Our correspondent does not say why, but we are led to infer that the pictures could not be entrusted to the tender mercies of gas. In the picture rooms several more chandeliers were erected, being made to represent flowers of all kinds. These were constructed by Messrs. Kraunne Schäffer, Hauschner, and Spinn. In all 200 A and 100 B lamps were employed, the dynamo machine being driven by one of Messrs. Ruston, Proctor, and Co.'s 16 h.-p. engines. The exhibition was visited by many notabilities, amongst others their Royal Highnesses the Crown Prince and Princess, all of whom were loud in their praise of the lights. Another installation of Edison's system has been made in the factory of Messrs. Rosenfeld and Co., of Cöpnick, sixty lamps being at present in use. The proprietors and *employés* are so pleased with the system that it is in contemplation to extend the number of lamps to 150. Both these installations were carried out by Mr. H. Warde, engineer to the Edison Company.

ELECTRIC LIGHTING FOR WALSALL.—At a meeting of the Walsall (Staffs.) Town Council recently, it was resolved to take all steps necessary to oppose the South Staffordshire and Incandescent Electric Lighting Companies, who had applied for provisional orders for that town. It was also stated that the council, in company with seven other boroughs, had retained Professor Jenkin, to advise them on scientific questions, and that the council proposed to see the insertion in any provisional order that might be made of clauses for the following purposes—viz.:—(1) Requiring the company to satisfy the Board of Trade, before commencing operations, that it has a sufficient amount of capital, and in the case of one company which sought to supply several towns, to allot to Walsall a certain amount of capital for the carrying out of the works; (2) that two companies shall not work on the same area; (3) that the council may have a voice in the selection of a site for the erection of the machine house; (4) that overhead lines shall be prohibited; (5) that all purchasers shall be put upon the same footing as regards price, and that the price for public lights shall be as low as to any other consumer; (6) that adequate powers shall be taken as to commencement and continuation of supply, and especially to prevent the companies suspending the supply two hours each night; (7) that in the case of the profits of the companies being increased by new inventions, or other causes, the public should get the advantage, as in the case of gas companies; (8) that the roads should be broken up only under the direction of the council; (9) that the companies should deposit or guarantee a sufficient sum for the completion of the work, and that the Corporation should have power to purchase at the end of fourteen years.

ELECTRIC LIGHTING IN NEWINGTON.—The Works and Sanitary Committee of the Newington Vestry have drawn up an exhaustive report on the proposed introduction of the electric light into that parish, from which we extract the following:—"The main question arising out of the subject of electric lighting is one of cost, and it is to this question that your committee have devoted considerable attention, with the view of not only assuring the vestry, but themselves individually as ratepayers, whether the adoption of the new illuminant is likely to be of any real benefit to the parish." Referring to an estimate from Messrs. Siemens Brothers to light the

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parish, the report goes on to state that "this estimate is calculated to displace 200 lamps of an illuminating power of 3,716 candles, and light the streets by 95 lights, of an illuminating power of 28,500 candles. The machinery, &c., necessary to supply electricity to these 95 lights was estimated to cost £8,000, while the maintenance charges reach £2,636 16s. per annum, whereas the cost of gas for the 200 lamps displayed amounts to £834 17s. 4d. per annum. It will be seen, therefore, that even if the vestry took up a loan of £8,000, repayable in fifteen years with interest at 4 per cent., the interest and instalments, together with the maintenance charge of £2,636 16s. for producing an illuminating power of 71,500 candles by electricity, is at least 45 per cent. less than the cost of the same illuminating power by gas. The gas company, if they contemplate deterring the vestry from supplying electricity, must make a considerable reduction in the price of gas, and then, if they do this, the ratepayers, instead of complaining, will have reason to be thankful that an expenditure of £20,000 (whether probable or actual) has been the means of bringing about this result. The interest and instalments on a loan of the sum named amount to a trifle over a penny rate in the pound, so that a person living in a house rated at £35 per annum may have to pay an increased rate of, say, 3s. in the year; but should the price of gas be reduced to only 2s. 6d. per 1,000 cubic feet, he would save 9s. in his gas bill, taking the consumption at 36,000 cubic feet per annum, which appears to be about a fair average for that class of house. In the case of a shopkeeper paying £42 10s. per annum for gas, the result is even more satisfactorily in favour of the ratepayer. For example, if occupying a house on Newington-causeway, he might probably be rated at £290, and his contribution towards the rates on a loan of £20,000 would be £1 4s. 2d. per annum, whereas the saving effected in gas, if only reduced in price 4d. per 1,000 cubic feet, would be £5, so that he would benefit through the action of the vestry to the extent of £3 15s. 10d. a-year. Having determined, therefore, not to advise the vestry to undertake an installation exceeding in first outlay £20,000, your committee have conferred several times with Mr. Shoolbred upon the area which should be included in the compulsory district, and as in determining this question the revenue for private lighting must not be lost sight of, your committee have arrived at the conclusion that the area of compulsory supply should be limited in the first place to the houses abutting on the Walworth-road, between the railway bridge and the New Kent-road, and thence along Newington-causeway to Union-road, and that the whole of the Elephant and Castle block, together with the houses and shops in Newington-butts, from Short-street to Draper-street, should be comprised in this area of supply." After a good deal of discussion the following resolution was adopted by the meeting, to which the above-mentioned report was submitted, viz.:—"That the draft license submitted in this report defining the area of compulsory supply in accordance with the provision of the Electric Lighting Act, 1882, be approved; that the memorial asking for the approval of the Board of Trade thereto be sealed, and that a cheque be drawn in favour of the Board for £50, to be deposited with the memorial in accordance with the rules issued by the Board."

Electrical Resistance of Selenium Cells.—In a paper recently read before the Physical Society, Mr. Shelford Bidwell criticises Dr. Moser's theory as to the effect of light in reducing the resistance of selenium cells. Briefly this theory is as follows:—Selenium reflects the invisible portions of the spectrum, absorbing principally the visible or illuminating rays; the vibrations thus taken up assume the form of heat; and the temperature of the cell is thereby raised. In consequence of this rise of temperature the selenium expands; it is accordingly pressed into closer contact with the electrodes, and, as in the case of the microphone, the resistance of the system is proportionately diminished. On the contrary, when the cell is screened from the light, the absorbed heat is radiated away, the selenium contracts to its original volume, and then its resistance becomes the same as at first. Mr. Bidwell tested this theory as follows:—"If it is true," he says, "that the observed effects are due merely to a rise of temperature, then it is clearly immaterial whether such rise of temperature is brought about by the heating action of light or by the direct application of heat in the ordinary way." Mr. Bidwell warmed some cells over a gas burner, with the following results. We quote from his paper:—"A selenium cell was placed in an air bath in absolute darkness, the bulb of a thermometer being very near its surface. The temperature of the air was 17deg. C., and the resistance of the cell at the beginning of the experiment was 140,000 ohms. The bath was then very slowly heated, and the resistances measured at every degree. At first, the rise was very rapid, then more gradual, until the temperature reached 23deg., when the maximum resistance of 150,000 ohms was attained. With continued heating the resistance fell, slowly at first, then more rapidly, then again slowly, the final measurement at 100deg. being only 16,000 ohms. [Note.—When the cell was removed from the air bath, its resistance in the dark in air at 18deg. was found to have increased to 90,000 ohms.] The same cell was afterwards submitted to the combined action of heat and light. A glass beaker was fitted with a wooden cover, to which the selenium cell was attached so as to hang perpendicularly inside the beaker; the beaker was placed in a sand bath, which was heated by a Bunsen burner, and the cell was illuminated by a powerful paraffin lamp at a distance of 30 centimetres. At 18deg. its resistance was only 19,000 ohms. As in the former case, the first application of heat was accompanied by a rise, though smaller and more gradual than before, the maximum of 24,000 ohms occurring at about 29deg. The fall which followed was also very gradual, the resistance at 100deg. being 10,000 ohms, or only 14,000 less than the maximum, as against a difference of 140,000 in the former experiment. In these experiments it might possibly be suspected that the initial small rise of resistance is due to some accidental disturbing cause, and does not point to any essential characteristic of selenium, or, rather, perhaps, of selenium cells." The following experiment seems, however, to settle the point conclusively:—One of my selenium cells did not at ordinary temperatures exhibit this peculiarity. When heated its resistance at once went down without any preliminary rise. This cell was placed in air at a temperature of 0 deg., and after remaining for half an hour its resistance was found to be 147,000 ohms. The temperature was then slowly raised, and, as I expected, the resistance at first went up, attaining a maximum of 219,000 ohms at 13deg., after which it went down to 134,000 ohms at 36deg., when the experiment was stopped. This particular cell differed from others only in the fact that it acquired its maximum resistance at a temperature slightly below instead of slightly above the average temperature of air. The supposition that light produces its effect by heating is further negatived by the fact that a comparatively high degree of temperature is required to bring down the resistance of the cell to the point to which it is instantly reduced by exposure to a strong light."

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ON THE ABSOLUTE MEASUREMENT OF ELECTRICAL RESISTANCE.*

BY PROFESSOR G. CAREY FOSTER, F.R.S.

A paper having the above title was read by Professor Foster at the meeting of the Physical Society on the 27th January. After pointing out the general principles on which the chief experimental methods hitherto employed for the absolute measurement of resistance are based, the author went on to give details of the method proposed by himself in 1874, at the meeting of the British Association in Belfast, and employed in experiments of which the results were communicated to the York Meeting in 1881, and published in *The Electrician* (Vol. VII., pp. 266, 267) for the same year. In this method the electromotive force induced by the earth's magnetism in a circular coil of wire revolving about a vertical diameter is balanced against the difference of potential required to maintain a current of known strength through the conductor whose resistance is to be measured. The absolute value of the electromotive force is known from the dimensions of the spinning coil, its rate of rotation, and the earth's horizontal magnetic force; the strength of the current is deduced from the deflection produced by it in a galvanometer of known dimensions, and from the earth's horizontal force; and the ratio of the electromotive force to the strength of current is the resistance required. The correctness of the results depends essentially upon the accuracy with which the dimensions of the spinning coil and of the absolute galvanometer can be measured. These were ascertained by measuring with a steel tape the circumferences of the brass rings on which the coils were wound, and then measuring again after each layer of wire had been put on. These measurements seemed to indicate that, in the case of the revolving coil, the layers of wire first wound on underwent a slight but perceptible compression by the outer layers, a result which is not surprising when it is considered that the normal pressure towards the axis of the ring, due to the whole coil consisting of 32 layers each containing 30 turns of wire, amounts to about $13\frac{3}{4}$ atmospheres. In the galvanometer coils there was evidence of a very slight effect of the same kind.

The conditions most favourable to sensitiveness were investigated by the late Mr. Charles Hockin, M.A., who showed (1) that the electromotive force of the battery employed to compensate the electromotive force of the coils should be *twice* that of the latter; (2) that the resistance of the spinning coil should greatly exceed that of the battery; (3) that the resistance of the absolute galvanometer should be equal to the resistance to be measured; (4) the resistance of the "zero galvanometer" (that is, the galvanometer used to show when the electromotive force of the coil is accurately adjusted) should equal the resistance of the coil, together with half the resistance to be measured. It was found practicable to make a sufficient approximation to these conditions in the experiments. At the speed of rotation mostly employed, about twelve turns per second, the electromotive force of the coil was very nearly 0·1 volt, and, as the compensating current was produced by a thermopile of electromotive force about 0·22, condition (1) was almost exactly fulfilled. The resistance of the coil being about 50 ohms, and that of the thermopile a small fraction of an ohm, condition (2) was also complied with. The resistances measured were from 70 to 80 ohms, and that of the absolute galvanometer about 60, thus nearly agreeing with condition (3). With the values already given, condition (4) would require the resistance of the zero-galvanometer to be about 90; the galvanometer actually employed had a resistance of 135.

The methods adopted for measuring the arc of contact of the commutator, and for adjusting the centre of the arc to the magnetic meridian, were described. The speed of the revolving coil was given by marks made on a moving strip of paper by a glass pen controlled by a small electro-magnet, the circuit of which was completed for an instant at every hundredth revolution, while seconds were marked on the strip by a similar pen acted on by a clock. The experiments hitherto made were not considered as anything more than trials of the method, but from this point of view they were regarded as satisfactory, the chief points in which improvement is required being the maintaining the speed of the coil sufficiently steady and measuring accurately the speed obtained.

The following table gives the results of the most important determinations of absolute resistance hitherto published. The numbers express the resistance of the B.A. standard of 1863 and 1864, the unit being *one earth-quadrant per second* :—

Observer.	Date.	Value.	
Lorenz	1873	... 0·9797	
Rowland	1876	... ·9912	
H. F. Weber ...	1877	... 1·002	(mean of three methods)
Lord Rayleigh ..	1881	... ·9893	(preliminary)
" "	1882	... ·9865	
Glazebrook	1882	... ·9866	
Kohlrausch	1870, corrected 1882	·990	
Lord Rayleigh ..	1883	... ·9868	

THE SHUCKERT MACHINE AND INCANDESCENT LIGHTING.

The Shuckert machine is, as is well known, a modification of the Gramme, and the first machines of this type were designed for arc lighting. In consequence, however, of the demand for machines for incandescent lighting, M. Shuckert is constructing special dynamos, known as type J. L., for this purpose, adapting them more especially for work with the Edison lamp. The E.M.F. at the terminals at the normal speed is about 110 volts, and it is estimated that generally there is a loss in the conductors of some 10 volts. Other incandescent lamps, such as the Swan, have to be arranged in compound series, so as to utilise this E.M.F. The following table gives some information regarding the machines of this type :—

TABLE RESPECTING J. L. MACHINES.

No.	E.M.F. in Volts.	Strength of Current in Amperes.	Indicated Horse-power.	Revolutions per Minute.	Number of Edison A Lamps.	Number of Edison B Lamps.
J. L. ½	110	3·6	1·0	1500	5	10
1		10·8	2·5	1300	15	30
2		18·0	4·0	1000	25	50
3		25·2	6·0	900	35	70
4		36·0	8·0	700	50	100
5		50·4	11·0	650	70	140

Fig. 1 shows the method of circuiting the A or B lamps. The greater part—say two-thirds—of the lamps can be cut out singly or otherwise without it being necessary to adjust

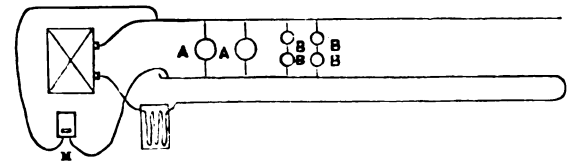

FIG. 1.—Method of Circuiting A or B Lamps.

the current regulator. In the parallel method effect depends upon the constancy of the E.M.F. and equality of current to the lamps. If these fluctuate, then the candle-power of the lamp varies. In order to check the E.M.F. a volt meter is put parallel with the wires of the first A lamp, as shown at M, irrespective of the remaining leads by two thin wires. The volt meter used with these machines will indicate up to 120 volts. In ordinary working the needle should indicate from 99 to 103 volts. With regard to the leads, it is recommended that the mains should consist of thick copper wire,

* Paper read before a meeting of the Physical Society, Jan. 27.

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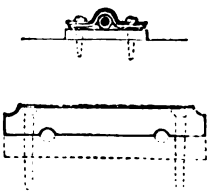
covered with incombustible insulating material. These main leads are fastened by wooden clamps, with perforations for support, as shown in Figs. 2 and 3. The branch wires used

Fig. 2.



Figs. 2 and 3.—Wooden Clamps for Leads.

are insulated with india rubber. The joints are soldered, and then covered with insulating material.

The size of the conducting wire is determined by the lengths. For the leads to the single lamps the following dimensions are suggested:—

Up to 100 m.	1 mm.
200 ,,	1·4 ,,
300 ,,	1·8 ,,
1,000 ,,	3·0 ,,

For the main leads the following dimensions are suggested:—

For 5 A Lamps.

Length.	Diameter.	Sectional Area.
Up to 100	1 mm.	0·785
200	1·4	1·57
300	1·7	2·36
400	2·0	3·14
500	2·3	3·93
600	2·5	4·72
700	2·7	6·28
900	3·0	7·07
1,000	3·2	7·85

From this table the diameter is calculated as follows:—

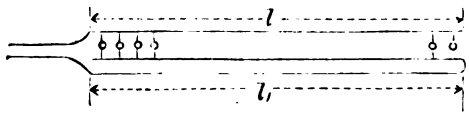


Fig. 4.—Diagram of Method of Obtaining Length of Main Leads.

In order to obtain the length L of the table, the lengths $l_1 + l = L$ are added, and the sectional wire area corresponding to the lengths looked out in the table. If the proposed plan n comprises A lamps (in which two B lamps are always reckoned equal to one A lamp), then the sectional wire area for the return lead $Q = \frac{n}{5} 9$ is to be taken for each of the two parallel wires with which the lamps are connected $Q = \frac{n}{7} 9$.

For plans of incandescent lamps, in which it is a question of greater distances, and where it is never required to extinguish single lamps, the T L machines are constructed, and by their use it is maintained that the dimensions of the wire required is diminished.

Table Respecting T L Machines.

No.	E.M.F. in Volts.	Strength of Current in Amperes.	H.-p.	Revolutions per Minute.	Allowable Lead Resistance in Ohms.	No. of B Lamps.	Parallel Series.
T L ½	55	7	1	1200 1500	0·6	10	1
1	105	8	2	1050-1100	0·6	22	2
2	160	8	3	800-1050	1·2	33	3
3	265	8	4	800 950	2·0	55	5
4	420	8	6 7	700-900	2·5	88	8
5	630-730	8	10-12	600-700	4·0	132-154	12-14

The dimensions of the wire of the leads to the single lamps are to be chosen as indicated above The main leads are to be reckoned in such a manner that the resistance does not exceed the amount given in the 6th vertical column.

For this calculation the following table is used:—

Wire thickness in mm.	7	6·5	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1
Resistance per 100 *m* ohms (*s*)	0·043	0·050	0·058	0·070	0·085	0·104	0·13	0·17	0·24	0·34	0·53	0·94	2·12

Fig. 5 shows the method of circuiting in series using the T L machines.

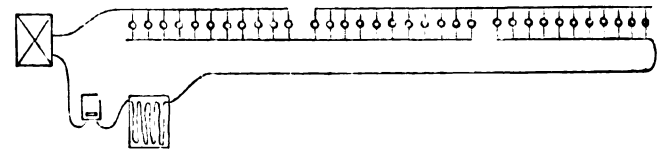


Fig. 5.—Method of Circuiting Lamps in Series.

In the case of the T L machines the working depends upon the constant maintenance of the strength of the current. It is therefore essential to put a current regulator and an ammeter in circuit. The ammeter must indicate up to eight amperes in ordinary working.

In order to be able with these machines to put out of circuit single lamps, or whole parallel series, it is necessary to have the compensation resistances which are to be put in circuit agreeably to the following plan:—A compensation resistance for a B lamp (70 ohms), parallel series for 11 B lamps (six ohms), and so on.

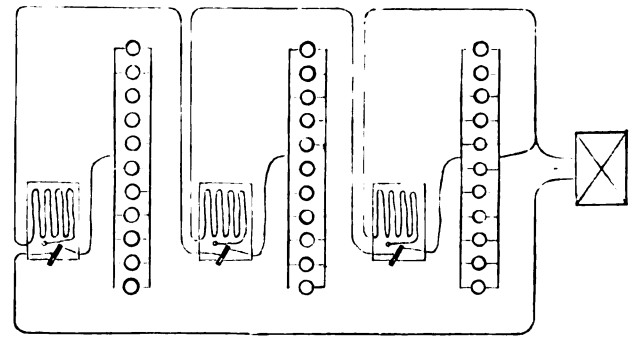


Fig. 6.—Method of Putting Compensation Resistances in Circuit for Parallel Series.

Fig. 6 shows the method adopted for putting in circuit compensation resistances for parallel series.

CANTOR LECTURES.*

Dynamo-Electric Machinery.

By Professor Silvanus P. Thompson, B.A., D.Sc., M.S.T.E.

Lecture II. (concluded).—The Dynamo in Practice.

(continued from page 257.)

Collectors.

In section *ab* of the first lecture, the main points to be observed in the construction of collectors are enumerated. Collectors of substantially such type as there described are common to all dynamos of the first class, except only the Brush dynamo, in which there is a multiple commutator, instead of a collector. The collector of Pacinotti's early machine differed only in having the separate bars alternately a little displaced longitudinally along the cylinder, but still so that the same brush could slip from bar to bar. Niaudet's modification, in which the bars are radially attached to a disc, is a mere variety in detail, and is not justified by successful adoption. In the collector, as used in Weston's dynamo, and in some forms of Schuckert's dynamo, the bars are oblique or curved, without, however, any other effect than that of prolonging the moment during which the brush, while slipping from contact with one bar to contact with the next, short-circuits one section of the coil.

In a well-arranged dynamo of the first class, the sections of the collector are traversed by currents, which run from the

* Reprinted from the *Journal of the Society of Arts*.

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negative brush in two directions round the successive coils, and meet at that bar of the collector which touches the positive brush. Each section of the coil thus traversed adds its own electromotive force to the current passing through it. Consequently, if one measures the difference of potential between the negative brush and the successive bars of the collector, one finds that the potential increases regularly all the way round the collecting cylinder, in both directions, becoming a maximum at the opposite side where the positive brush is. This can be verified

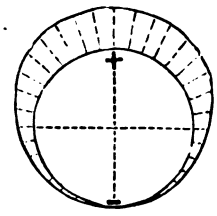

FIG. 25.—Diagram of Potential round the Collector of Gramme Dynamo.

by connecting one terminal of a voltmeter to the negative brush, and touching the rotating collector at different points of its circumference with a small metallic brush or spring attached by a wire to the other terminal of the voltmeter. If the indications thus obtained are plotted out round a circle corresponding to the circumference of the collector, the values give a curve like that shown in Fig. 25, which is plotted out from observations taken upon a Gramme dynamo.*

It can be seen that, taking the negative brush as the lowest

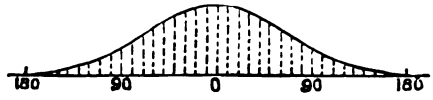

FIG. 26.—Horizontal Diagram of Potentials at Collector of Gramme Dynamo.

point of the circle, the potential rises perfectly regularly to a maximum at the positive brush. The same values are also plotted out as ordinates upon a horizontal line in Fig. 26. This form of diagram shows very clearly that the rise of potential is not equal between each pair of bars, otherwise the curve would consist merely of two oblique straight lines, sloping right and left from the central point. On the contrary, there is very little difference of potential between the collector bars close to the + brush on its right and left respectively. The greatest

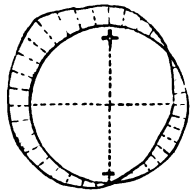

FIG. 27.—Diagram of Potential round the Collector of a Badly-arranged Dynamo.

difference of potential occurs where the curve is steepest, at a position nearly 90° from the brushes, in fact, at that part of the circumference of the collector which is in connection with the coils that are passing through the position of best action. Were the field perfectly uniform, the number of lines of force that pass through a coil ought to be proportional to the sine of the angle which the plane of that coil makes with the resultant direction of the lines of force in the field, and the rate of cutting the lines of force should be proportional to the cosine of this

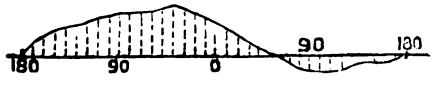

FIG. 28.—Horizontal Diagram of Potentials at Collector or Faulty Dynamo.

angle. Now the cosine is a maximum when this angle = 0°; hence, when the coil is parallel to the lines of force, or at 90° from the brushes, the increase of potential should be at its greatest—as is very nearly realised in the diagram of Fig. 26, which, indeed, is very nearly a true "sinusoidal" curve. Such curves, plotted out from measurements of the distribution of potential at the collector, show not only where to place the brushes to get the best effect, but enable us to judge of the relative "idleness" or "activity" of coils in different parts of the field, and to gauge the actual intensity of different parts of the field while the machine is running. If the brushes are badly set, or if the pole-pieces are not judiciously shaped, the rise of potential will be irregular, and there will be maxima and minima of potential at other points. An actual diagram, taken from a dynamo in which these arrangements were faulty, is shown in Fig. 27, and again is plotted horizontally in Fig. 28; from which it will be seen, not only that the rise of potential was irregular, but that one part of the collector was more positive than the positive brush, and another part more negative than the negative. The brushes, therefore, were not getting their proper difference of potential: and, in part of the coils, the currents were actually being forced against an opposing electromotive force.

I believe that this method of plotting the distribution of potential round the collector will prove very useful in practice, and will explain various puzzling and anomalous results found by experimenters who have not known how to explain them. In a badly-arranged dynamo, such as that giving such a diagram as Fig. 27, a second pair of brushes, applied at the points showing maximum and minimum potential, could draw a good current without interfering greatly with the current flowing through the existing brushes! In fact, I find that this bad distribution, giving rise to anomalous maxima and minima, has actually been patented by a gentleman of the name of Kennedy,* who puts brushes on *six* different points of a collector!

Curves, similar to those given, can be obtained from the collectors of any dynamo of the first class—Gramme, Siemens, Edison, &c.—saving only from the Brush machine, which, having no such collector, gives diagrams of quite a different kind. It is, of course, not needful in taking such diagrams that the actual brushes of the machine should be in contact, or that there should be any circuit between them, though in such cases the field-magnets must be separately excited. It should also be remembered that the presence of brushes, drawing a current at any point of the collector, will alter the distribution of potential in the collector; and the manner and amount of such alteration will depend on the position of the brushes, and the resistance of the circuit between them.

The Brush Dynamo.

Before passing on to the dynamos of the second class, I have some remarks to make on that much mis-understood and mis-described machine, the Brush dynamo. Its armature—a ring in form, not entirely overwound with coils, but having projecting teeth between the coils like the Pacinotti ring—is unique. Though it thus resembles Pacinotti's ring, it differs more from the Pacinotti armature than that armature differs from those of Siemens, Gramme, Edison, Bürgin, &c.; for in all those the successive sections are united in series all the way round, and constitute in one sense, one continuous bobbin. But in the Brush armature there is no such continuity. The coils are connected in pairs, each to that diametrically opposite it, and carefully isolated from those adjacent to them. For each pair of coils there is a separate commutator, so that, for the ordinary ring of eight coils, there are four distinct commutators side by side upon the axis—one for each pair of coils. The brushes are arranged so as to touch at the same time the commutators of two pairs of coils, but never of two adjacent pairs; the adjacent commutators being always connected to two pairs of coils that lie at right angles to one another in the ring. The arrangement is best studied graphically from the diagram given in Fig. 29. In this figure, the eight coils are numbered as four pairs, and each pair has its own commutator, to which pass the outer ends of the wire of each coil, the inner ends of the two coils being united across each other (not shown in the diagram). In the actual machine, each pair of coils, as it passes through the position of least action (*i.e.*, when its plane is at right angles to the direction of the lines of force in the field, and when the number of lines of force passing through it is a *maximum*, and the rate of change of their lines of force a *minimum*) is cut out of connection. This is accomplished by causing the two halves of the commutator to be separated from each other by about one-eighth of the circumference at each side. In the figure it will be seen that the coils marked 1, 1, are "cut out." Neither of the two halves of the commutator touches the brushes. In this position, however, the coils 3, 3, at right angles to 1, 1, are in the position of best action, and the current powerfully induced in them flows out of the brush marked A (which is, therefore, the negative brush) into that marked A'. This brush is connected across to the brush marked B, where the current re-enters the armature. Now, the coils 2, 2, have just left the position of best action, and the coils, 4, 4, are beginning to approach that position. Through both these pairs of coils, therefore, there will be a partial induction going on. Accordingly, it is arranged that the current, on passing into B,

* This diagram was plotted for me, and the measurements made at my request, by Mr. W. M. Morley, who first drew my attention to some of the abnormal phenomena mentioned later.

* British Patent, No. 1,640 (1882).

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splits, part going through coils 2, 2, and part through 4, 4, and re-uniting at the brush B′, whence the current flows round the coils of the field-magnets to excite them, and then round the external circuit, and back to the brush A. (In some machines it is arranged that the current shall go round the field-magnets after leaving brush A′, and before entering brush B; in which case the action of the machine is sometimes, though not correctly, described as causing its coils, as they rotate, to feed the field-magnets and the external circuit alternately.) The rotation of the armature will then bring coil 2, 2, into the position of least action, when they will be cut out, and the same action is renewed with only a slight change in the order of operation. The following table summarises the successive order of connections during a half-revolution:—

First position. (Coils 1 cut out.)

A—3—A; B $\left\langle \begin{smallmatrix} 4 \\ 2 \end{smallmatrix} \right\rangle$ B; Field-magnets—External circuit—A.

Second position. (Coils 2 cut out.)

A $\left\langle \begin{smallmatrix} 1 \\ 3 \end{smallmatrix} \right\rangle$ A; B—4—B; Field-magnets—External circuit—A.

Third position. (Coils 3 cut out.)

A—1—A; B $\left\langle \begin{smallmatrix} 2 \\ 4 \end{smallmatrix} \right\rangle$ B; Field-magnets—External circuit—A.

Fourth position. (Coils 4 cut out.)

A $\left\langle \begin{smallmatrix} 3 \\ 1 \end{smallmatrix} \right\rangle$ A; B—2—B; Field-magnets—External circuits—A.

responding to the cut out position; and again, on each side of the negative brush there is a region where the polarity is the same as that of the negative brush. Fig. 30 is a diagram of a 6-light Brush taken at one commutator, the main + brush being, however, allowed to rest (as in its usual position), in contact with both this commutator and the adjacent one.

From the foregoing considerations it will be clear that the four pairs of coils of the Brush machine really constitute four sepa-

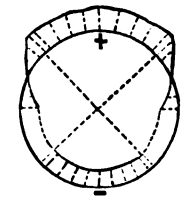

FIG. 30.—Diagram of Potentials at Commutator of Brush Dynamo.

rate machines, each delivering alternate currents to a commutator, which commutes them to intermittent unidirectional currents in the brushes; and that these independent machines are ingeniously united in pairs by the device of letting one pair of brushes press against the commutators of two pairs of coils. Further, that these paired machines are then connected in series, by bringing a connection round from brush A′ to brush B.

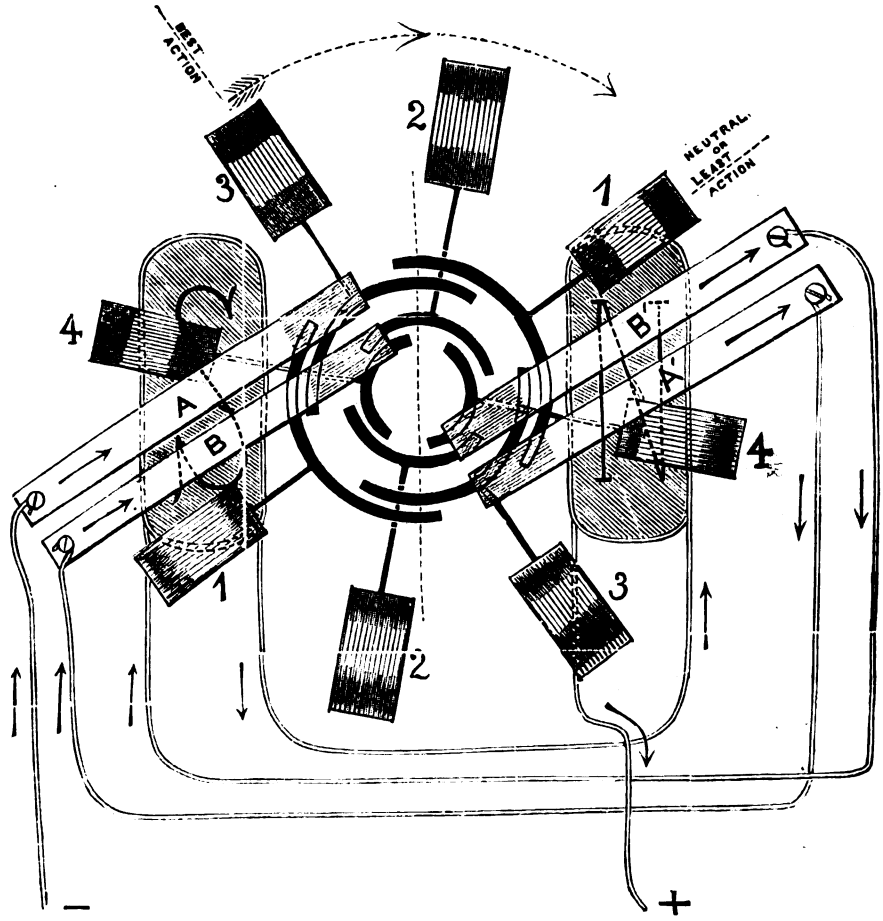

FIG. 29.—Diagram of the Brush Dynamo.

From this it will be seen that whichever pair of coils is in the position of best action, is delivering its current direct into the circuit; whilst the two pairs of coils which occupy the secondary positions are always joined in parallel, the same pair of brushes touching the respective commutators of both.

One consequence of the peculiar arrangement thus adopted is, that measuring the potentials round one of the commutators with a voltmeter gives a wholly different result from that obtained with other machines. For one-eighth of the circumference on either side of the positive brush there is no sensible difference of potential. There then comes a region in which the potential appears to fall off; but the falling off is here partly due to the shorter time during which the adjustable brush connected with the voltmeter and the fixed positive brush are both in contact with the same part of the commutator. Further on there is a region in which the voltmeter gives no indications cor-

The following experiment illustrates the independence of the four pairs of coils in the Brush dynamo.* The usual commutators of a small Brush dynamo were removed and replaced by eight brass collars, to each of which was united one end of one of the four pairs of coils. Against these rings pressed eight separate brushes, and the circuit of each of the four pairs of coils was completed, as shown in Fig. 31, through an ordinary detector galvanometer. On rotating the armature by hand, at a moderate speed, the needles of all four detectors are set vibrating to and fro by the alternate currents, not synchronously, but one after the other. If any one of the four circuits are broken, the others go on as before.

* This beautiful experiment was first shown me by Mr. P. Allen, who kindly fitted up the little Brush dynamo with the eight collars for this occasion.

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Dynamos of the Second Class.

I now pass on to dynamos of the second class, in which coils are carried round to different parts of a magnetic field, whose intensity differs in different regions, or one in different parts of which the lines of force run in opposite directions. Fig. 9 of my first lecture illustrated this principle; and we shall now consider how it is carried out in practice. In the early machine of Pixii a single pair of coils was mounted so as to pass in this fashion through parts of the field where the magnetic induction was oppositely directed. Such a machine, therefore, gives alternate currents, unless a commutator be affixed to the rotating axis. Niaudet's dynamo, which may be regarded as a compound Pixii machine, having the separate armature coils united as those of Gramme and Siemens into one continuous circuit, is furnished with the radial collector mentioned above. In the Wallace-Farmer dynamo is very neatly realised the condition of field of Fig. 9, there being a pair of poles at the top arranged so that the north faces the south pole, and another pair at the bottom where the south faces the north pole. The coils are carried round, their axis being always parallel to the exis of rotation upon a disc, there being two sets of coils on opposite faces of two discs of iron set back to back. They are united precisely as in Niaudet's dynamo, and each disc has its own collector. Each bar of the collector is, moreover, connected, as in the dynamos of Pacinotti, Gramme, Siemens, &c., with the end of one coil, and the beginning of the next. In fact, the Wallace-Farmer machine is merely a double Niaudet dynamo with cylindrical collectors. There is a serious objection to the employment of solid iron discs such as these. In a very short time they grow hot from the eddying Foucault currents engendered in them as they rotate. This waste reduces the efficiency of the dynamo. In the dynamo of Hopkinson and Muirhead the disc armature takes a more reasonable shape. Instead of a solid disc of iron to support the coils, there is a disc built up of a thin iron strip wound spirally round a wooden centre. The coils, of approximately quadrangular shape and flat form, are wound upon the sides of this compound disc. The dynamo of Ball (the so-called "Arago-disc" machine) is similar in many respects, but has no iron cores to the armature coils.

Alternate-current Dynamo.

But by far the most important of the dynamos of this second class are those usually known as *alternate-current machines*. This type of dynamo was originally created by Wilde, in 1867. The field magnets consist of two crowns of fixed coils, with iron cores, arranged so that their free poles are opposite to one another, with a space between them sufficiently wide to admit the armature. The poles taken in order round each crown are alternately of north and south polarity, and opposite a north pole of one crown faces a south pole of the other crown. This description will apply to the magnets of the alternate current machines of Wilde and Siemens, to the so-called Ferranti machine, and, with certain reservations, to the machines of Lachaussée and of Gordon. The armature in almost all machines of this type consists of a *disc*, bearing at its periphery a number of coils, whose axes are parallel to the axis of rotation. The principle will be best understood by reference to Fig. 32, which gives a general view of the arrangement. Since the lines of force run in opposite directions between the fixed coils, which are alternately S—N, N—S, as described above, the moving coils will necessarily be traversed by alternating currents; and as the alternate coils of the armature will be traversed by currents in opposite senses, it is needful to connect them up, as shown in the figure, so that they shall not oppose one another's action.

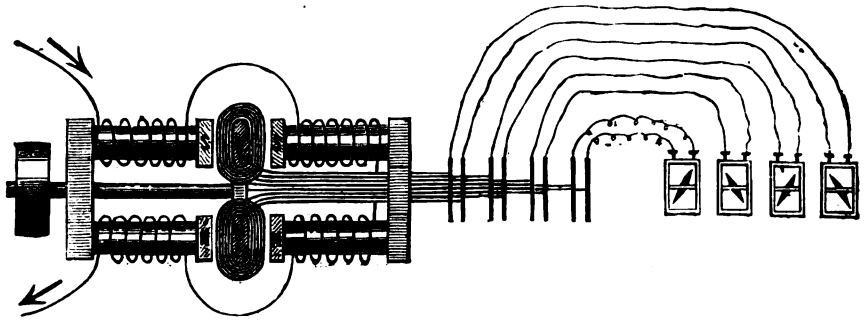

FIG. 31.—Brush Dynamo Arranged with four Detector Galvanometers, showing alternate current induced in independent pairs by coils.

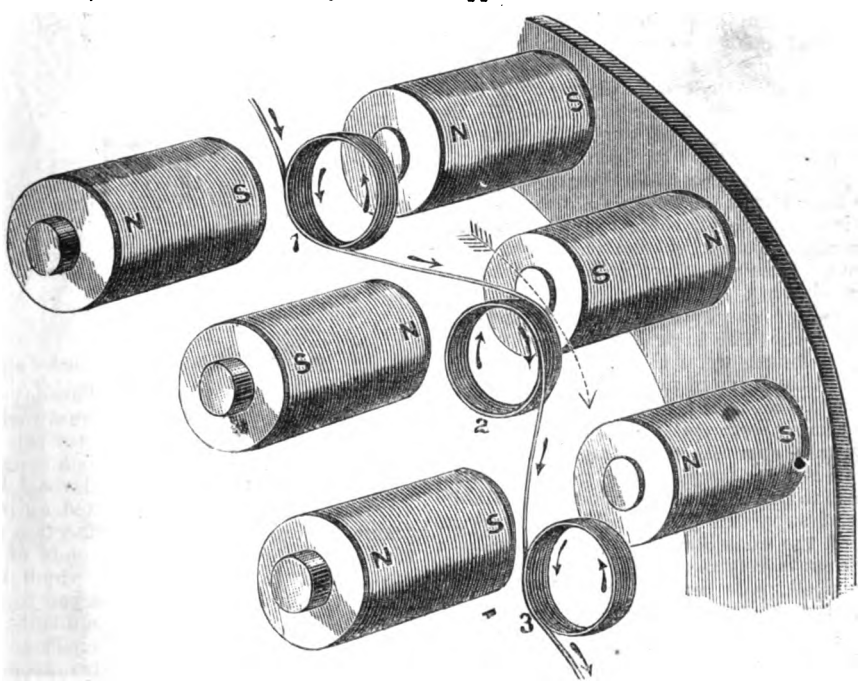

FIG. 32.—Principle of Alternate-Current Dynamos.

In Wilde's dynamo, the armature coils have iron cores, and the machine is provided with a commutator on the same principle as that used by Jacobi in his famous motor of 1838, consisting of two metal cylinders, cut like crown wheels, having the teeth of one projecting between those of the other, so that the brushes make contact against them alternately as they rotate. The brushes are, of course, fixed, so that they do not both touch the same part. This commutator Wilde usually applied to a few, or only one, of the rotating coils, and utilised the current thus obtained to magnetise the field magnets. The main current was not so commuted, but was led away from a simple collector, consisting of two rings connected to the two ends of the armature circuit, each being pressed by one brush.

Siemens prefers to use a separate direct current machine to excite the field magnets of alternate-current dynamo. In the

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armature of the latter the coils are wound usually without iron, upon wooden cores. In some forms of the machine, the individual coils are enclosed between perforated discs of thin German silver. When currents of great strength are required, but not of great electromotive force, the coils are coupled up in parallel arc, instead of being united in series.

In a dynamo by Lachaussée, which very strikingly resembles the preceding one, there is iron in the cores of the rotating coils. But the main difference is that the rotating coils are the field magnets, excited by a separate Gramme dynamo, whilst the coils, which are fixed in two crowns on either side, act as armature coils in which currents are induced.

Gordon's dynamo, the largest yet made, is constructed on the same lines as the Lachaussée machine; but with many important improvements. In the first place, there are twice as many coils in the fixed armatures as in the rotating magnets, there being 32 on each side of the rotating disc, or, in all, 64 moving coils; while there are 64 on each of the fixed circles, or 128 stationary coils in all. The latter are of an elongated shape, wound upon a bit of iron boiler plate, bent up to an acute V form, with cheeks of perforated German silver as flanges. The object of thus arranging the coils, so that the moving ones shall have twice the angular breadth of the fixed ones, is to prevent adjacent coils of the fixed series from acting detrimentally, by induction, upon one another. The alternate coils of the fixed series are united together in parallel arcs, so that there are two distinct circuits, in either or both of which lamps can be placed; or they can be coupled up together. Great care appears to have been taken, in the construction of this large machine, to guard against the appearance of Foucault currents, by arranging the cores, frames, and coils, so that all metal parts of any size shall be slit, or otherwise structurally divided at right angles to the direction of the induced electromotive forces.

Yet another alternate-current dynamo, identical in many respects with the Siemens alternate-current dynamo, has lately been brought out, under the name of the Ferranti machine. As in the machines of Wilde and Siemens, the electro-magnets form two crowns with opposing poles. The point of difference is the armature, which, like that of Siemens, has no iron cores in its coils; but which, unlike that of Siemens, is not made up of coils wound round cores, but consists of zigzags of strip copper folded upon one another. There are eight loops in the zigzig, and on each side are sixteen magnet poles; so that, as in Gordon's dynamo, the moving parts are twice the angular breadth of the fixed parts. The advantage of the armature of zigzag copper lies in its simplicity of construction. Sir W. Thomson, who is the real inventor of this armature, proposed originally that the copper strips should be wound between projecting teeth on a wooden wheel. He also proposed to use as field magnets a form of electro-magnet of the kind known as Roberts's, and also used by Joule, in which the wires that bring the exciting current are passed up and down, in a zigzag form, between iron blocks projecting from an iron frame. I am not aware that this particular suggestion has been adopted as yet in practice.

Much more might be said concerning the two machines last described—the Gordon and the Thomson dynamos—but time does not permit me to dwell longer upon them. And, indeed, I am not at all convinced that this type of machine, though at present it appears to be the fashionable one, is destined to prove of such very great value, simply because I doubt whether any dynamo that yields alternate currents can compete with continuous-current machines. For the purposes of a general system of distribution, where more than one dynamo must be available, and also for the purpose of supplying motors, alternate-current machines are quite out of the question. I will not, therefore, dwell longer upon them, than merely to remark that, besides the disc armatures now described, pole armatures have been employed in alternate-current machines by Gramme, Jablochkoff, and by Lontin. Hefner Alteneck has gone a stage further, and, by the device of employing a disc armature in which the number of coils differed by two, or some other even number, from those of the field, and by the employment of a multiple-bar collector with complicated cross connections, has succeeded in converting this type of dynamo into a continuous-current machine.

Thomson's "Mouse-mill" Dynamo.

One other dynamo, not belonging to the type I have been dealing with, is worthy of mention. This is Sir W. Thomson's "mouse-mill" dynamo. I have noticed, *en passant*, several points in this machine—the form of its field magnets and their coils, the internal electro-magnets, &c. The armature is a hollow cylinder, made up of parallel copper bars, arranged like the bars of a mouse-mill (whence the name of the machine). These bars are insulated from each other, but are connected all together at one end. At the other, they serve as collector-bars, and deliver up the currents generated in them to the "brushes." As the armature is a hollow barrel, with fixed electro-magnets within, it cannot be rotated on a spindle, but runs on friction rollers, by one or more of which it is driven.

Dynamos of the Third Class.

I now come to the third class of dynamos—those in which rotation of a conductor effects a continuous increase in the number of lines of force cut by the device of arranging one part of the conductor to slide on or round the magnet.

The earliest machine which has any right to be called a dynamo was, in fact, of this class. Barlow and Sturgeon had shown that a copper disc, placed between the poles of a magnet, rotates in the magnetic field when traversed by an electric current from its axis to its periphery, where there is a sliding contact. Faraday, in 1831, showed that by rotating a similar disc mechanically between the poles of a magnet continuous currents were obtained. These he drew off by collecting springs of copper or lead, one of which touched the axis whilst the other pressed against the amalgamated periphery. He was thus "able to construct a new electrical machine."* "Here, therefore, was demonstrated the production of a permanent (*i.e.*, continuous) current of electricity by ordinary magnets." But Faraday did not stop short with ordinary magnets; he went on to employ the principle of separate excitement of his field magnets. "These effects were also obtained from *electro-magnetic poles*, resulting from the use of copper helices or spirals, either alone or with iron cores. The directions of the motions were precisely the same; but the action was much greater when the iron cores were used than without."† The invention of the dynamo dates, therefore, from 1831, and Faraday was its inventor, though he left it to others to reap the fruits of his splendid discovery.‡ Such a machine, however, is impracticable, for several reasons. The peripheral friction is inadmissable on any but a small scale; moreover, the disposition of the field-magnets necessarily evokes wasteful eddy-currents in the disc, which, even if slit radially, would not be an appropriate form of armature for such a limited magnetic field.

Another method of obtaining a continuous cutting of the lines of force is indicated in Fig. 33, where a sliding conductor travels

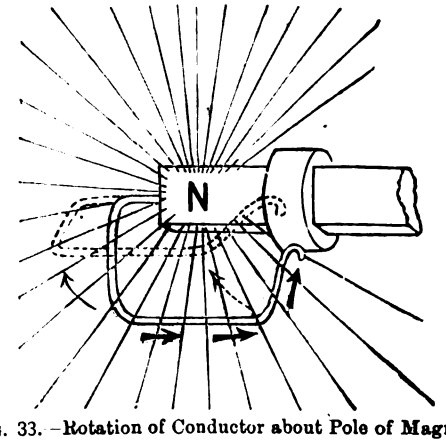

Fig. 33.—Rotation of Conductor about Pole of Magnet.

round the pole of a magnet. Faraday even generated continuous currents by rotating a magnet with a sliding connection at its centre, from which a conductor ran round outside, and made contact with the end-pivots which supported the magnet.

A similar arrangement was devised by Mr. S. Alfred Varley, about the year 1862. He rotated an iron magnet in a vertical frame, having a mercurial connection at the centre. The current which flowed from both ends of the magnet toward the centre was, in this machine—which, by the kindness of Mr. Varley, I am able to exhibit to you to-night—made to return to the machine, and to pass through coils surrounding the poles of the rotating magnet, thus anticipating the self-exciting principle of later date. Mr. Varley also proposed to use an external electro-magnet to increase the action.

Quite recently the same fundamental idea has been worked upon by Messrs. Siemens and Halske, who have produced a so-called "unipolar" machine.§ In this remarkable dynamo there

* "Experimental Researches," § 83. † "Experimental Researches," § 111.

‡ "Experimental Researches," § 158:—"I have rather, however, been desirous of discovering new facts and new relations dependent on magneto-electric induction, than of exalting the force of those already obtained; being assured that the latter would find their full development hereafter." Can any passage be found in the whole range of science more profoundly prophetic, or more characteristically philosophic, than these words, with which Faraday closed this section of his researches.

§ This sounds like a *locus a non lucendo*, for the machine has two poles. But the name is derived from the term "unipolar induction," which Continental electricians give to the induction of currents by the process of "continuous cutting," which we are now dealing with. I do not adopt the term, as it is needlessly mystifying.

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are two cylinders of copper, both slit longitudinally to obviate eddy-currents, each of which rotates round one pole of a U-shaped electro-magnet. A second electro-magnet, placed between the rotating cylinders, has protruding pole-pieces of arching form, which embrace the cylinders above and below. Each cylinder, therefore, rotates between an internal and an external pole of opposite polarity, and consequently cuts the lines of force continuously by sliding upon the internal pole. The currents from this machine are of very great strength, but of only a few volts of electromotive force. To keep down the resistance, many collecting brushes press on each end of each cylinder. This dynamo is actually at work for electro-plating.

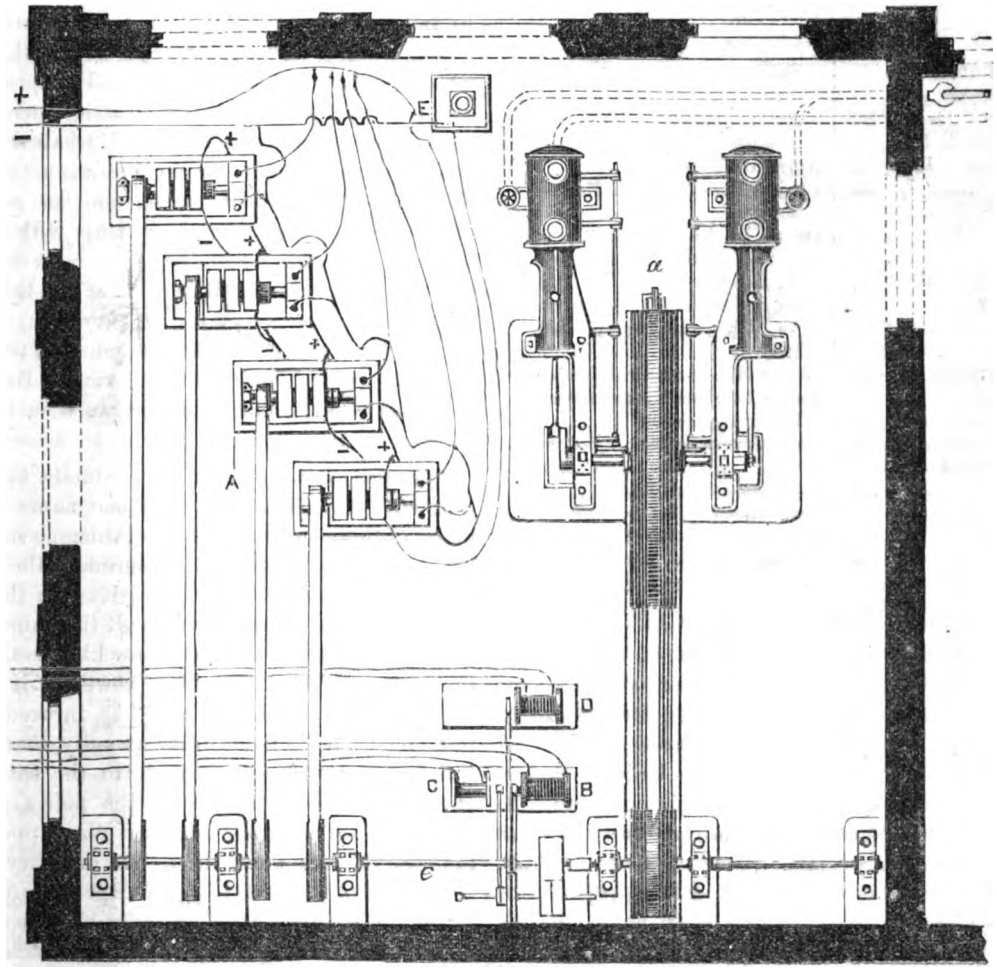
The only other dynamo of this class, of which I have seen any published notice, is one recently patented by Mr. E. L. Voice, in which a coil armature, wound upon an iron ring, is so placed that the iron ring is itself one pole of a magnet, a projecting pole-piece from the other pole being fixed near it, so that the coils fixed upon one pole glide round and cut the lines of force proceeding from the other pole. Whether this machine will be a practical one remains to be seen.

We are, however, far from having arrived at finality in the design and construction of dynamo-electric machines. All we can yet say is that we appear to be approaching the time when practice will no longer be a species of blundering along into success or failure. For every day theory is more and more brought to bear in practice, and will soon enable us to predict with certainty beforehand what will be the merit of a dynamo of any particular design: and even to say not only what its cost will be, and what its efficiency and maximum duty, but also how many volts of electromotive force, and how many amperes of current it will put at our disposal. In short, the application of theory in the manufacture of dynamos must rapidly lead to great and substantial improvements in the dynamo in practice.

(TO BE CONTINUED.)

ARRANGEMENT OF MACHINES AT BRÜNN.

The accompanying diagram of the arrangement of the machines at Brünn Theatre explains itself. The engine and boiler are in an adjacent building, and were built by the Estern Brünnen Machinen-Fabriks-Gesellschaft. There are three boilers—two in general use, one in reserve. The illustration shows the method of connecting the machines, and this is, perhaps, the most important use of such illustrations for students, many of whom may be called upon, sooner or later, to arrange installations themselves. The work has been carried out under the Société Electrique Edison of Paris. The machines run from 10 to 2 daily for rehearsal, and in the evening from 5:30 to 10:30, making a total of nine hours daily. The experiment at Brünn is due more especially to the enterprising Herr Gustav Winterholler-Bürgermaister of Brünn, who built the theatre. As is usual in questions of progress, there was a good deal of opposition encountered and overcome before the work could be commenced. However, energy succeeded, and success has silenced the adverse critics.



Machine Room at the Brünn Theatre.

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NOVEL USES FOR ELECTRICITY.

It has often been said in disparagement of science and invention that we owe our most useful discoveries to accident. Generalisations such as these are of no practical value except perhaps to enemies of the patent laws, who never condescend to particulars. Whatever truth there may be in the assertion, a general statement of quite opposite import would be true to the same extent, such for example as that the most baneful or mischievous discoveries, assuming there are any, have been due to mere accident also. Both propositions have something to be said for them, and both alike must be urged with much reservation. The part that accident has played in the field of discovery is a very uncertain one, and on one point only can we speak with confidence, namely, that accident is perfectly impartial in its operations, doing us an ill turn with as much unconcern as it does us a good one.

It was nature and not inspiration that revealed to us the deadly powers of electricity. This was a long while ago; and, ever since we were able to take an intelligent view of the revelation, no pains have been spared to devise means for safeguarding our fellow creatures from its consequences, some men indeed having sacrificed their lives in the endeavour. It did not occur to anybody to "invent" a form of lightning in order to kill his neighbour; on the contrary, the chief occupation of the ingenious in this branch of science was for many years that of applying electricity to therapeutic uses, healing the sick, and even resuscitating the seemingly dead, being among the chief objects aimed at. This was turning the tables on nature, giving her, so to speak, a lesson in humanity. But we have changed all that. True the newspapers invite us pictorially to purchase curative appliances, and we are still entreated to throw physic to the dogs, putting our trust in "nature's remedy," meaning of course a mild dose of lightning. But these things are for the infirm. For the more robust, mentally, as well as constitutionally, Mr. Lane-Fox, the *Medical Press*, and certain correspondents of the daily press, have lately proffered suggestions more startling and more tangible. According to one of these authorities electricity ought to be utilised for the slaughtering of aged horses; according to another we ought to adopt the same means for doing to death our condemned criminals; whilst a third, the medical paper above mentioned, warns us against the surreptitious use of the electrical current for the purposes of secret murder.

All this we may safely affirm is the result of pure accident, of several accidents in fact, whereby people have been killed by lightning of man's devising. We could have well spared this discovery, and so perhaps could the aged horses, for whose prompt despatch Mr. Lane-Fox proposed to utilise it. We do not want to see the electric current diverted to the use of private assassination; and, whatever the assassin himself may say about it, we do not want to annihilate him by the same agency. But, unwelcome as may be the fact we must put up with it as we put up with dynamite and the other deadly sins. They have all been turned to harmless account, and we expect the same of the killing capabilities of electricity. There is nothing, therefore, to be said against Mr. Lane-Fox's or the correspondents' proposals considered from the utilitarian point of view. But there are other points of view besides this, and we wish to dwell upon them for a moment.

The proposal to slaughter animals by electricity is not original. Dr. Richardson, whose name is associated with many curious suggestions, tried this one some years ago. We do not exactly know why. Nominally the idea was to cause a painless death. Human experience in these matters is very limited, and as we cannot consult the animals it is impossible to affirm what sort of death they like best, and which one is the least painful. As a fact, however, it was found, firstly, that the meat so slaughtered was injured, some of it being rendered unfit for food; and, secondly, that the animals sometimes came to life again, much to the satisfaction no doubt of the professional wielder of the pole-axe, though probably not to that of the poor beasts. We suppose we must allow that the doctors know best, but ordinary people who have seen a bullock stunned by an experienced hand, attach very little significance to the struggles that may afterwards ensue. Sensation is extinguished with the first blow—at all events the sensation of pain. Some creatures are very stupid, and others very unreasonable. A hen, for example, will run away minus her head, and we all know what eels are capable of in the way of obstinately presuming to live. But nobody supposes that feeling survives the first slash of the knife, or if it does survive, all we can say is that the amount of prolonged cruelty inflicted on fish and poultry calls for the interposition of the humane far more than does the case of

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the higher creation, who, if they feel more acutely, die much more quickly.

But there was one other objection to Dr. Richardson's proposal, and it applies equally to Mr. Lane-Fox's for the slaughtering of used-up horses, namely the danger to the slaughterers. We understand that the animal is to stand on a metallic floor, which is connected to an electrical appliance of great power, and this in turn to a wire and a knob. If the horse's forehead comes in contact with the knob the horse will be stricken dead. Given an intelligent horse duly trained to touch the knob, and the business is done. To train and persuade an average slaughterer to bring the knob to the horse would be not more easy, and far less safe. This and the combined protest of every old maid against the injury done to the food of their favourite pets may be trusted to keep Mr. Lane-Fox's device out of the knacker's yard for a long while yet to come.

As to substituting an electric wire for a hempen cord, we think we discussed this proposal once on a former occasion. The number of transactions lately quoted, especially from the sister isle, may now for a moment tempt the proprietors of new inventions lacking customers to embark in that line of business. But only for a moment. One difficulty we feel confident would prove insurmountable, that of finding an—well, an operator. There is, as we have already said, much beside mere utility to be taken into account in work of this sort, not the least of which is sentiment, and what we have hitherto called self-respect. Some rough things have still to be done in this world, which had better be done roughly, for if performed scientifically they would in reality be rendered more barbarous for all the parties concerned.

We suppose it is the business of the medical profession to look after our safety in matters relating to secret homicide, otherwise we could hardly excuse the *Medical Press* even hinting at the possibility of murder by means of the electric current. The danger seems purely imaginary, especially as the impossibility or improbability of discovering the cause of death is, we feel sure, a complete mistake. Let the medical profession look to it, however, if we are wrong, for we confess that electrical science would be somewhat at a loss to act as detective *after* the work was done. Perhaps our security from this kind of danger, if any such threaten us, lies in the absence of technical skill, and the risk to the operator himself. Let us hope so at least, and hope, too, that the accidental discovery of the dangers attending unskilful handling of a powerful electric current may not lead to its use for any of the purposes we have here commented upon.

CORRESPONDENCE.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reference to Mr. Rathbone's letter, I quite understood his remark, and in reply draw his attention to the G.S. spring, the function of which is not only to provide a path for the current but also to *prevent* the possibility of a disruptive effect taking place in the circuit at the point of contact on the transmitter being subjected to too loud speaking, such as would occur were no such preventive measure taken, and which does take place when the small spring sticks to the diaphragm by rust, and is thereby prevented from acting, with the result which is patent to all who have had any practical experience with the instrument; therefore it is, in this form of transmitter, absolutely necessary.

I pointed out in one of my former letters that the effect of pressure (in the microphonic sense) on carbon exists within certain limits; and I have not the slightest doubt, if he can devise a means of fixing binding screws to a piece of carbon *without exceeding* and being somewhat within *this limit*, together with a suitable means for mounting same, maintaining a constant initial pressure, he will be quite successful. I might mention in passing that I have examined many Crossley-Gower and other dead-weight contact transmitters, but with entirely the reverse effect which he anticipates. But more of this particular class of transmitter at some future date, the introduction of which at present would only render the argument more complex.

This correspondent states that the reason carbon alters its resistance more than brass is due to *form*, not *material*, which I confess is good going Greek to me if this statement is to be accepted in the literal sense, but on reading further I am under the impression that he means texture of surface. If this is right, I beg to inform him that the higher the polish on the carbon button, the better the action, and in cases where the polish has been accidentally destroyed by rough usage or bad packing when in transit, it becomes necessary to renew the surface and repolish it. It is clear, then, that this argument falls to the ground. He further says some very fine brass filings with a little dust thrown in, would show a more variable resistance. Where has this to be thrown, into the button, or in the eyes of the uninitiated?

I am obliged to "W. E. H." for calling my attention to the paragraph referring to circuit resistance, which scarcely conveys my meaning. If he will remove the period following "diaphragm" and put it after "diminished," the new sentence will then run, "A corresponding diminution of current takes place when the pressure is removed," to which he can add, "and the button allowed to regain its normal resistance."

In the experiment mentioned, illustrating the action of a blow on the masses suspended, first, he will allow that the force or energy of the blow must have a certain ratio to the weight of the masses suspended to produce displacement, and that, if a sufficiently light blow be given, the total energy would be absorbed by the elastic bodies themselves without causing any displacement whatever. Therefore, *a distinct blow may be given without the outermost mass being disturbed, so far as actual contact is concerned.* 2nd. In the case of three masses being suspended, his argument would hold good with a blow of a given energy, and with no other force but that of gravity acting on each of them equally and in the same direction; but how widely different is the effect when we come to consider the action of a spring on the same terms. It will be sufficient to consider the G.S. spring only. If he takes a Blake and examines this spring he will find, when the carbon button is removed, the spring will lift the platinum stud outwards (*i.e.*, in the direction of the carbon block when in position) and upwards, while gravity would pull it downwards, and in a direct line with its suspension. The resultant of these two forces would be closely approximate to a right angle with the line of suspension, and be in the *direct line with the thrust*, therefore its natural tendency is to fulfil the function for which it is designed, viz., the *maintenance of a closed contact.* It is clear, then, that I agree with your correspondent that the spring modifies the action of gravity in the matter, and to what degree he may satisfy himself if he takes the trouble to remove the spring carrying the platinum stud from a Blake and suspend in its place a platinum bead by a single thread of gimp. If he is then content with the instrument as a transmitter—and contentment means happiness—he is a happy man, indeed. I will now endeavour to reduce the foregoing to practice.

It so happens when testing a transmitter it is usual to ascertain how delicate and responsive it is to subdued speech. Suppose he were to take a properly adjusted Blake, and whisper or speak in a moderate way to it. The whisper will be perfectly well heard, the impulses will correspond to the light blows by which a displacement of the parts is impossible. If he will now shout a sentence at the pitch of his voice so as to correspond with the heavy blows and produce the necessary displacement, would the sentence be understood by the

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receiver? Certainly not. Instead of speech being transmitted there would be nothing conveyed but a jarring noise.

The sum total of all this simply proves, and by his own argument, that speech is not produced in a Blake transmitter by an intermittent contact. "He is a poor engineer who is hoist with his own petard."

If W. E. H. has any other substance which will act *as well as carbon*, I will be much pleased to receive a sample of it. The difference of the action between carbon and brass points to one conclusion only, which is unnessary for me to reiterate.

I am sorry, Mr. Editor, I cannot induce this gentleman to sign his name.

I have read "Gordius's" letter with interest. His final experiment would seem to be somewhat similar to a Hunning transmitter, but not having seen the instrument, I can pass no opinion on it. If he could spare a pair for a few days, I would like very much to make a trial of them. He does not state how many Leclanchés would be required to excite them.—Yours &c, R. D. SMILLIE, Electrician.

National Telephone Company (Limited), Glasgow.
Jan. 25th, 1883.

THE STORAGE OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Reading the interesting address delivered by Mr. Willoughby Smith at the Society of Telegraph Engineers on the 18th inst., I am a little surprised at the few remarks made on the above subject. We know the storage of electricity is a great desideratum, but when it is said that two years have passed away without any useful results following the importation of the marvellous box from Paris, which was so graphically described by Sir William Thomson, or, in other words, that no progress has been made in this direction, this, I think, is a slight mistake, as the storage cells known as the Sellon-Volckmar accumulators, an improvement on the wonderful boxes of M. Faure, are giving useful results. I cannot conceive a more suitable purpose than telegraphy to which secondary cells might advantageously be applied. What could be more simple, clean, and economical than a set of these cells, and a small gas motor? I have no hesitation in saying that accumulators *properly* constructed on the above plan should last at least five years. At the end of that time it would not take as many hours to replace the worn out plates.—Yours, &c., H. A. KENT.

154, Culford-road, N., Jan. 29, 1883.

FITTINGS FOR INCANDESCENT LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With your permission I would venture to call attention to the different fittings for incandescent lamp sockets now in use. There are, I believe, no less than three different sockets for Swan lamps, one having 7-16in. female fitting, one $\frac{3}{8}$in. male fitting, and one with the so-called "burner size," 5-16in. taper thread. The Lane-Fox have two sockets, one with 7-16in. and one $\frac{3}{8}$in. female fitting. The Duplex use 5-16in. taper thread, and Maxim uses $\frac{3}{8}$in. female for his sockets. All sockets for Edison lamps have hitherto had $\frac{3}{8}$in. female fitting. I would suggest that some universal size be adopted by all the companies for their sockets. This would make the various systems, so far as the lamps and sockets are concerned, interchangeable, and would be of great convenience, not only to individuals but to manufacturers at large.

I think attention to such details as these would go far to take away the opinion, at present far too prevalent, that electric lighting needs much simplyfying before coming into general use.—Yours, &c., J. B. V.

THE RECTIFICATION OF ALCOHOL BY ELECTRICITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your editorial of August 26, 1882, you state that alcohol is open to electrical treatment both for "ageing" and rectification. Will you or any of your readers kindly oblige by giving any information you may have respecting such treatment, or say where I could find particulars for myself?—Yours, &c., READER.

STATIC ELECTRICITY AND QUANTITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Sprague, on page 231, I must in the first place respectfully decline the suggested perusal of the work to which he alludes.

If we take matter for granted we know force only as change of momentum, and therefore we must necessarily define force in terms of certain changes in the state of matter. If, on the other hand, we take force for granted, we have to define matter in terms of force. Mr. Sprague takes exception to Professor Clifford's definition of force as the change of momentum of a body considered as depending upon its position relative to other bodies on the ground that force cannot *be* change of momentum, and, metaphysically, I think the statement is open to objection, just as we may object to the statement that the velocity of a body moving uniformly is the space described in unit time. The full statement of this would be—The velocity of a body moving uniformly is that state of the body in virtue of which it changes its position in space, and is measured by the space traversed in unit of time. We might in the same way say that, the force acting upon a body owing to its position relative to other bodies is that state of the system of bodies in virtue of which the given body changes its momentum, and is measured by the change in the momentum of the given body in an unit of time, supposing the unit of time to be taken so small that that state is sensibly the same at the beginning and end of the interval. The usual expressions are certainly preferable on the score of simplicity, and with ordinary attention to the meaning of words they do not seem to me to be liable to misconception. Mr. Sprague says that unit force and unit energy are the same. Now, force is a directed quantity and energy is not, which is quite sufficient to show that force and energy cannot be the same thing.

The argument from Faraday's ice-pail experiments is a direct deduction from the experimental results, and does not depend upon any theory of electricity, and it is certainly no answer to the argument to say that it has been "thoroughly misunderstood."

With regard to Mr. Sprague's complacent opinion that Maxwell was gradually adopting his views, and that "most of the leading electricians are unconsciously adopting the same course," discussion is unnecessary, as the opinion can do no harm to any one, and probably gives satisfaction to Mr. Sprague. As Mr. Sprague "does not care to go into questions of dimensions," permit me to point out to any of your readers who have not considered the subject, that a physical equation, the members of which were of different dimensions in the fundamental units, would involve the absurdity that the truth of the equation would depend on the units of length, time, and mass employed.

Mr. Sprague finally quotes an illustration of Sir William Thomson's of the well-known fact that electrical conductivity is, in the electrostatic system of units, of the same dimensions as velocity, but to this he adds the totally incorrect statement that a current is a velocity. Now, a velocity is a length divided by a time, but electric current is a quantity of electricity divided by a time; that is, the dimensions of current are, in the electrostatic system, $L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-1} \times T^{-1} = L^{\frac{3}{2}} M^{\frac{1}{2}} T^{-2}$, while those of velocity are $L T^{-1}$.—Yours, &c.,

G. W. VON TUNZELMANN.

IMPROVED GALVANIC BATTERY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: After carefully reading over the description of Mr. Parkhurst's improved galvanic battery in your issue of the 20th inst. (Slip), I cannot exactly see how the action de-

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scribed takes place. If any of the subscribers to your valuable paper would give the chemical formula for the action I think it would make the description clearer, as well as supply a very interesting equation. The above information would greatly oblige—Yours, &c., CHEMICAL AFFINITY.

ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As a subscriber to *The Electrician*, I beg to trouble you with the following questions, and hope that you will answer them in your next issue:—

I want to make some accumulators (I have already done so on a small scale, and have succeeded so far as the energy and duration of the current is concerned) which can be charged by a small dynamo made purposely for this work, and which is sold at the office of *L'Electricité*, 16, Rue Croissant, Paris, at 400 francs.

Now, the E.M.F. of this dynamo is 80 volts, and the current in amperes 9 (one of these, however, is required for the field magnets); what will be the number and weight of accumulators that I can charge with this dynamo, so as to give me, when discharged, sufficient current for one Swan incandescent lamp of $2\frac{1}{2}$ carcels, or an Edison A or B lamp? If I knew the weight required in these cases, I could make a battery for ten or twenty lamps.

What number and weight of accumulators can I use, the tension of which shall not overcome that of the dynamo when charging?

I should be much obliged if you or your readers could help me in the matter.—Yours, &c., J. H. DISERENS.

Care of Mr. P. A. Moussy, Manufacture des Soieries.
Moscow, January 8/20, 1883.

A SAFETY LAMP FOR MINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 27th instant you devote a paragraph to the "Electrical Safety Lamp for Mines." Will you permit me to make one or two corrections? In the first place, Mr. Ellis Lever is not an M.P., and is not to be confounded with the member for Galway, the two being in no way connected. Secondly, there is an error in the address; it is Culcheth Hall, Bowden. Thirdly, the offer of £500 is not confined to electric lamps, though, no doubt, that will be the light most likely to fulfil all the required conditions, and, therefore, will, in the near future, be the miners' safety light, and best guide in this hazardous calling.

It might be interesting to your readers to know that Mr. Ellis Lever, who has made this handsome offer, is the father of Mr. Charles Lever, whose arc lamp you noticed some time since, and who is now lighting up the Tropical Department at the Crystal Palace with a new and improved arc lamp.—Yours, &c., GEO. HOWELL.

City Club, Ludgate-circus, E.C.,
Jan. 30, 1883.

ANSWER TO CORRESPONDENT.

X.—Awaiting the completion of foreign patents.

BOROUGH OF SHEFFIELD.

ELECTRIC LIGHTING ACT, 1882.—PRELIMINARY REPORT OF CONRAD W. COOKE, M.S.T.E. & E.

The corporation of the Borough of Sheffield having resolved to apply to the Board of Trade for a provisional order under the Electric Lighting Act of 1882, authorising them to supply electricity for public and private purposes within the said borough, and I having been requested by the corporation of the said Borough of Sheffield to advise them as consulting engineer with respect to the said provisional order, and the carrying out of the provisions therein contained, I beg to submit the following preliminary report:—

The application of the science of electricity to industrial purposes, especially to the production of artificial illumination, the transmission of mechanical power to a distance, and the allied industries of electro-plating and electro-typing has, during the last few years, made such important progress that it may fairly be said to have passed from the experimental region of the laboratory of the physicist to take its place amongst the recognised industries of the world; and the International Exhibition held at Paris in 1878, and still more emphatically the Exposition d'Electricité which was held in the same city last year, have demonstrated to the public the practical capabilities of the application of electricity to illumination as well as to other hardly less useful industrial purposes. The result of these practical demonstrations has been that a strong and insatiable public demand for electricity has arisen, and a large and rapidly-increasing number of electrical installations has sprung up in every civilised portion of the globe, but especially in this country, in France, Belgium, and Germany, and in the United States of America.

The lighting of a considerable number of the streets of Paris and London was quickly followed by other towns, and a new branch of industry has arisen out of this public demand of such magnitude that electric lighting companies, with capital in the aggregate amounting to several millions of pounds, have been formed in bewildering numbers, and the question has become of so much public importance as to demand the recognition of the Legislature. In August of the present year the Electric Lighting Act of 1882 was added to the statutes, and this was immediately followed by a set of rules issued by the Board of Trade with respect to applications for licenses and provisional orders.

The immediate consequence of the passing of this Act was that the corporations of nearly all the important towns in the United Kingdom were applied to and served with notices from some five or six electric lighting companies, or other proprietors of systems of electric supply, of their intention to apply for licenses or provisional orders for the establishing, in each of the towns applied to, electric power generating stations, workshops and machinery, with powers for the breaking up of the public streets and highways for the purpose of laying the conductors or electric mains, and for the doing of all such things as are necessary to the establishment of electrical installations upon a large scale.

The giving consent to the obtaining of provisional orders for such purposes to private companies or individuals would virtually amount to the abandonment of the rights of corporations and other local authorities to the control of the streets and highways within their own boroughs or districts over which they have had hitherto and would have otherwise control; and there has been a very general and very decided feeling on the part of corporations and other local authorities, to resist so serious an interference with their rights within their respective districts.

To prevent this interference there appears to be but one course open to the local authority of a borough or district, and that is (in accordance with Rule II. of the Board of Trade rules), themselves to apply for a provisional order to supply electricity within their borough or district, and thus maintain in their own hands the control of their streets and highways, and at the same time not place their town behind other towns in the adoption of electric illumination, which, at no very distant period, must, in my opinion, be generally adopted for town lighting.

In order to comply with the requirements of the Board of Trade I am advised that, although it is open to the Corporation of Sheffield to apply for a provisional order specifying the area of supply to be the whole area of the borough as constituted under the provisions of the Acts relating to municipal corporations, it is not necessary to take compulsory powers for the whole of that area, but in order to show that the corporation has, in applying for an order, a *bonâ fide* desire to make a substantial trial of the electric light within the borough, and not merely to keep others from supplying electricity therein, it is necessary that the corporation, in applying for a provisional order, shall undertake, within a specified time, to give a supply of electricity for private purposes within a certain district of the town, such district not being necessarily very large, as compared with the area of the whole borough, but that throughout that limited district they must bind themselves to supply at a uniform rate of remuneration any intending consumer who may apply for it.

I would, therefore, propose that the corporation should, in connection with the provisional order, undertake to make an experimental lighting of a certain limited area of the town, and by "area" I do not mean an area in the ordinary acceptation of the word—bounded by a circular or polygonal boundary, and embracing every house within it—but a selection of a few of the most important streets specified in a schedule to the provisional order, and not to include (except in instances likely to prove ad-

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vantageous or desirable) the smaller streets and blocks of buildings included within the meshes formed by the network of streets proposed to be included in the district to be lighted.

I have prepared a plan indicating the district over which I would propose to supply electricity for private purposes, which might be distributed from a single supply station placed upon any land sufficiently near to the installation that could advantageously be obtained by the corporation, or, preferably, from two stations situated respectively at or near the opposite ends of the district to be lighted. The district I would recommend the corporation to illuminate (as a preliminary step, and in order to comply with the rules of the Board of Trade) embraces a series of streets extending, generally speaking, from north-east to south-west, that is to say, from the river end of Waingate, near to the Lady's Bridge, to the southern end of Pinstone-street, near to Moorhead and to Barker Pool, near the Albert Hall, and consists of the following streets and thoroughfares, the houses and other buildings belonging to which should be included in the area of compulsory supply:—

(1) Waingate.	(8) Market-place.
(2) Castle Folds.	(9) High-street.
(3) Castle-street.	(10) Church-street.
(4) Angel-street.	(11) Leopold-street.
(5) King-street.	(12) Fargate.
(6) OldHaymarket.	(13) Barker Pool.
(7) Market-street.	(14) Pinstone-street.

The above series of streets measures in the aggregate about a mile and a quarter, and represents rather over two miles of house frontage, seventy-five per cent. of which is occupied by shops.

Leaving for future consideration the *public* lighting of the above district, I will confine myself to the illumination of the houses and shops which are directly belonging to the streets of which it is composed, and the first question which presents itself for consideration is whether the illumination shall be effected by arc lights or by incandescence lamps, or by a selected combination of the two. There cannot be a doubt that for large open spaces, for large halls and for many factories and mills the illumination by the electric arc is the most convenient, as it is the most economical, but on the other hand it is a system that requires a certain amount of skilled attendance, and the lamps employed require to be fitted with new carbon pencils every day, and not only have the carbons to be supplied but certain adjustments have occasionally to be made to the lamps. These operations, though simple in themselves to any one accustomed to them, are such as would prevent my recommending any arc system for indiscriminate private lighting, for which purpose it is impossible for the apparatus within a private house to be too simple, being as it is more or less in the hands of domestic servants and other unskilled people.

For the above reasons I am bound to recommend for the general lighting of the district the principle of lighting by incandescence, of which, as the corporation knows, there are several systems owned by as many proprietors. I would, therefore, recommend the laying out of the installation as if nothing but incandescence lights were to be employed, but I would, at the same time, point out that the doing so does not *necessarily* exclude the employment of arc lights in special cases where they might be more suitable, for it is quite possible—although I do not recommend it—to substitute an arc lamp for a corresponding number of incandescence lamps, and thus have both arc lights and incandescence lamps burning on the same circuit. I should prefer (if there were a demand for arc lights sufficient to justify the outlay), the laying of a separate circuit for them, and actuated by a separate dynamo machine or series of machines, so that the one system would be perfectly independent of the other, but whether this should be done or not can only be determined by the local opinion and other local circumstances.

The attendance required with incandescence lights is simply the turning them on or off, as required, and the renewal of lamps when destroyed, and as the average life of an incandescence lamp is several thousand hours, and its renewal is as simple an operation as putting a candle into a candlestick, the attention required by consumers is altogether inconsiderable, and does not even include any lighting operation except the turning on of a small tap-like "switch."

For uniform and steady illumination there is nothing to be desired in incandescence lights, they are perfectly steady, being subject to no fluctuation—which cannot be said of the very best arc lamp at present in the market—although all the arc lamps employed to any considerable extent at the present time are great improvements on those of but a few years ago, and I have no doubt arc lighting will be still further improved by the introduction of regulating lamps still more readily adjusting themselves to the variations of the current transmitted through them, and side by side with these improvements the system of the self-adjustment of dynamo machines to the work put upon them from time to time will become more and more developed.

In order to arrive at anything like an accurate estimate of the amount of illumination required, that is to say of the number of lights of a given photometric value that will be necessary to be supplied with electricity, I would suggest that the occupiers of premises belonging to the district to be lighted be asked the number of lights they would require (estimating at about eight electric incandescence lamps for every ten gas burners at present employed), or if that be considered inadvisable, a reliable person might be requested to survey the district with the object of estimating as nearly as possible, the number of gas-lights at present employed in the shops and other buildings attached to the streets mentioned in the schedule, and from an estimate so produced the number of equivalent electric lights might be computed.

In the absence of such information, and for the purpose of making a general estimate of what may be considered the requirements of the installation, I have taken an average number of houses throughout the district by considering every 24 feet run on each side of the street as representing one house, and upon this method of computing I take it that there are 550 average houses in the district. In a district consisting of private dwelling-houses and but few shops it is fair to estimate that the illumination by incandescence lamps may be effected by allowing an average of ten lamps per house of an average frontage of 24 feet, upon which calculation there would be required 5,500 lamps. Inasmuch, however, as the district consisting of the streets set forth in the schedule on page 2 of this report is composed, in so large a proportion, of shops likely to require a larger number of lights, I think it would hardly be safe to estimate a smaller number of lights per house than eighteen, which would bring the number of lamps for the district to 10,000. It is not in the least degree probable that every proprietor in the district would adopt the electric system at once, and we may assume that there will be a considerable number who will refuse to adopt it altogether. On the other hand, there will be others (and I expect many among the proprietors of important shops) who will require a larger number of lamps than the estimated allowance of eighteen lamps for every 24 feet of frontage, and so the deficiency of some will be made up by the greater demand of others.

To drive these ten thousand lamps I estimate would require about 1,250 actual horse-power when all working together. This power estimated at about an eighth of a horse-power per lamp is, I am aware, greater than that quoted generally by proprietors of electrical incandescence systems, who, as a rule, state that an average of ten twenty-candle lamps can be driven per horse-power, but I do not feel justified in recommending the adoption of a less driving power than one horse-power to every eight lights; but this estimate is an outside one, and should allow a margin for ensuring easy working.

I would here point out that under most of the recognised incandescence systems the cutting out of lamps is accompanied by a corresponding saving of motive power, and, therefore, of fuel consumed, so that if at any time 100 lamps be in operation, or 1,000, or 10,000, the power absorbed will bear a proportionate relation to the number of lights in actual operation.

It may be of some service if I in this place give a few figures by way of roughly estimating the probable cost of such an installation, and which may be divided under three headings, that is to say:—

I.—Producing or Generating Plant.
II.—Distributing Plant.
III.—Fixed Property.

I. Producing or Generating Plant may be divided into two sections:—

(1) *Motive Power.*
Consisting of
- (*a*) Steam engines.
- (*b*) Boilers.
- (*c*) Steam and other fittings, shafting, &c.

(2) *Electric Apparatus*:—
Consisting of
- (*a*) Dynamo electric machines.
- (*b*) Indicating, testing, and other accessory apparatus—such as switches, cut outs, meters, &c.

II.—Distributing Plant:—
1. Electric mains and conductors.
2. Distributing boxes.
3. House service lines.

III.—Fixed Property:—
1. Land.
2. Buildings.

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CAPITAL REQUIRED.

I.—PRODUCING PLANT:—

(*a*) Six 250 I.H.P. compound steam engines, *i.e.*, five working and one in reserve at £750	£4,500		
(*b*) Six Lancashire boilers at £780	4,680		
(*c*) Pipes and connections	1,000		
(*c*) Fixing, &c.	1,000		
		£11,180	
Twelve 1,000-light dynamo-electric machines, at £800	£9,600		
Fixing, starting, &c.	1,000		
		£10,600	
			£21,780
		£2 3s. 6d. per lamp.	

II.—DISTRIBUTING PLANT:—

(*a*) 6,250ft. of streets, with mains laid on both sides, at £3,000 per mile	£7,200	
(*b*) 60 distributing boxes, at £8	480	
(*c*) 400 house service lines, at £3	1,200	
	£8,880	£8,880
	17s. 9d. per lamp.	

III.—FIXED PLANT:—

(1). Land, (2). Buildings ... Estimated together at	£10,000	
		£10,000
	£1 per lamp.	

IV.—To which may be added for contingencies, engineering, &c., at 10 per cent. £4,066

£0 8s. 2d. per lamp.

£44,726

Total capital £4 9s. 5d. per lamp.

A.—The above figures are on the assumption that the boilers employed are of the ordinary Lancashire type, and the engines are compound high and low pressure non-condensing engines.

(B).—Should it be decided to adopt compound high and low pressure condensing engines so as to effect the greatest possible economy of fuel with Lancashire boilers, the item for motive power must be increased to £15,530, estimated as follows:—

Five 300 i.h.-p. compound engines—that is four to work and one in reserve—delivered and set at £1,700 each	£8,500
Foundations for ditto	900
Nine Lancashire boilers, seven working and two spare, delivered on setting at £450 each	4,050
Boiler settings	1,080
Pipes, floor plates, &c.	1,000
	£15,530

(C).—If, on the other hand, "locomotive" boilers be decided upon, in order to occupy a minimum of space and to be able to get up steam very quickly, the item for motive power will become £16,700, made up as follows:—

Five compound engines, as above	£8,500
Foundations for ditto	900
Seven "locomotive" boilers at £870 each	6,090
Settings for ditto	210
Pipes, floor plates, &c.	1,000
	£16,700

SUMMARY.

(A).—If compound non-condensing engines be employed—

Electric apparatus	£10,600	
Motive power	11,180	
Distributing plant	8,880	
Land and buildings	10,000	
	£40,660	
Contingencies, engineering, &c., 10 per cent.	4,066	
		£44,726

(B) If compound condensing engines and Lancashire boilers be employed:—

Electric apparatus	£10,600	
Motive power	15,530	
Distributing plant	8,880	
Land and buildings	10,000	
	£45,010	
Contingencies, engineering, &c., 10 per cent.	4,501	
		£49,511

C.—If compound condensing engines and "locomotive" boilers be employed—

Electric apparatus	£10,600	
Motive power	16,700	
Distributing plant	8,880	
Land and buildings	10,000	
	£46,180	
Contingencies, engineering, &c., 10 per cent.	4,618	
		£50,798

The above figures are further summarised in the following table:—

CAPITAL.	With Compound High-pressure Engines and Lancashire Boilers. A	With Compound Condensing Engines and Lancashire Boilers. B	With Compound Condensing Engines and "Locomotive" Boilers. C
Electric apparatus	£10,600, = £1 1s. 2d. per lamp.	£10,600, = £1 1s. 2d. per lamp.	£10,600, = £1 1s. 2d. per lamp.
Motive power	£11,180, = £1 2s. 4d. per lamp.	£15,530, = £1 11s. per lamp.	£16,700, = £1 1s. 4d. per lamp.
Distributing plant	£8,880, = 17s. 9d. per lamp.	£8,880, = 17s. 9d. per lamp.	£8,880, = 17s. 9d. per lamp.
Land and buildings	£10,000, = £1 per lamp.	£10,000, = £1 per lamp.	£10,000, = £1 per lamp.
Contingencies, engineering, &c.	£4,066 = 8s. 2d. per lamp.	£4,501, = 9s. per lamp.	£4,618, = 9s. 3d. per lamp.
Total	£44,726, = £4 9s. 5d. per lamp.	£49,511, = £4 18s. 11d. per lamp.	£50,798, = £5 1s. 7d. per lamp.

(TO BE CONTINUED.)

ON THE MOLECULAR RIGIDITY OF TEMPERED STEEL.*

BY PROFESSOR D. E. HUGHES, F.R.S.

During the course of some recent researches the writer has been enabled by the aid of the induction balance to perceive some remarkable molecular differences between the constitution of iron and of steel.

There are numerous papers in the *Comptes Rendus* from 1830 to 1850, in which it is suggested that tempered steel is a true alloy of iron and carbon, the carbon being present in varying degrees according to the temperature at which the alloy was formed, and being afterwards rendered permanent by sudden cooling.

In a late discussion on this subject† the writer made a few remarks, in which he pointed out the marked difference between softened and tempered steel, as to solubility in dilute sulphuric acid, and expressed the opinion, formed from these and many previous experiments, that tempered steel was a true alloy.

He has since continued these experiments, not, however, to prove the chemical composition of tempered steel, but to investigate its peculiar molecular structure, as indicated by the induction balance.

The apparatus necessary to perceive the effects of stress or torsion, as described in this paper, is exceedingly simple. Suppose, for instance, that we take an ordinary single-coil electro-magnet, and join its terminals with that of a telephone or sensitive galvanometer. If we now pass a current from a battery through the iron core alone of the electro-magnet we have a sharp click at each make and break of the current. This effect was discovered by Page, and fully described by De La Rive.‡

If we keep the current passing constantly through the core we have no effect, but if we then give a slight torsion or twist to the core either to the right or left we at once hear a sharp click; and if we keep the torsion constant and then make frequent interruptions of the battery we have a greatly increased sound at each make or break, indicating a greatly increased force of electric current.

In order to investigate this phenomenon the author constructed a special though very simple apparatus.

A coil having a large aperture is fixed to a board; two small

* Paper read at the Meeting of the Institution of Mechanical Engineers on Thursday, Jan. 25.

† *Proceedings* of the Institution, 1880, p. 233.

‡ De La Rive. "Treatise on Electricity," vol. I., chap. v. London, 1853

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abutments or supports at a few inches distance on each side of the coil allow us to suspend or fix an iron wire passing through the aperture, which then becomes the core of an electro-magnet. This forms the essential portion of the apparatus. The iron or copper wire rests upon the two supports, which are 20 centims. apart; at one of these it is firmly clamped by two binding screws, while the opposite end can turn freely. The wire is 22 centims. long, projecting two centims. beyond its support. On the projecting end is a key or arm, which serves as a pointer moving on a graduated circle, and gives the degree of torsion which the wire may receive. A binding screw allows us to fasten the wire, after turning the pointer to any degree of torsion, and thus preserves the required stress as long as is necessary.

The exterior diameter of the coil is 5½ centims., and that of the interior vacant aperture 3½ centims.; the width is two centims. Upon this coil is wound 200 metres of No. 32 silk-covered copper wire. This coil is fastened to a small board, so arranged that it can be turned through any desired angle in relation to the iron wire which passes through its centre; and it can also be moved so as lie over any portion of the 20 centims. length of wire, in order that different portions of the same wire may be tested under a similar stress.

The whole of this instrument, as far as possible, should be constructed of wood, in order to avoid all disturbing inductive influences of the coil upon other pieces of metal.

The iron wire at its rear or fixed end is joined to or makes contact with a copper wire, which returns to the front part of the dial under the board and parallel to the coil, thus forming a loop. The free end of the iron wire is joined to one pole of the battery; the copper wire under the board is joined to a rheotome, and thence to the other pole of the battery.

The coil is joined to a telephone or a sensitive galvanometer; and we may either pass the current in the manner described, or may reverse all the communications, passing the current through the coil instead of the wire, and listening with the telephone to the induced currents upon the iron wire alone.

In order fully to understand the phenomena which takes place, we must bear in mind Faraday's discovery of electric magnetic induction, namely, that any wire conveying an electric current induces in general a momentary secondary current in any independent circuit whose wires are parallel to it; the effect being at its maximum when two wires are parallel, diminishing as the angle of these wires is increased, and at 90deg. being absolutely zero. Consequently, when we place a copper wire in the axis of the coil, with the above apparatus, and pass a current through this wire, we find no effect whatever, no trace of induced currents; simply for the reason that this copper wire crosses all of the wires of the coil at an angle of 90deg. We also find that no effect takes place upon torsion being applied to the copper wire. If we now place a small rod of iron parallel with the conducting copper wire, we have no effect; but if the iron rod is turned at an angle to the wires a current is observed, the force increasing from parallelism to an angle of 45deg., and decreasing again from this angle to 90deg., where we have again no effect. The conducting copper wire thus induces electric magnetism in the iron rod, and this magnetism reacts upon the coil; but this only holds as long as the rod is not parallel to either coil. At an angle of 90deg., although at its maximum of electric magnetism, the iron rod becomes parallel to the coil upon which it reacts; consequently we have again a zero of current. In place of one rod, we may insert several short rods, and if these are all turned together in the same direction, we have similar effects.

Knowing this, we can understand that if each molecule of a rod were endowed with separate magnetic power, and if we could cause these to rotate through any angle round the axis, we might expect similar reactions to those of the small separate iron rods already mentioned.

If we replace the copper wire spoken of by an iron wire, and send intermittent currents through it, we still have no induced current upon the coils; but the instant we apply a very slight torsion, say 10 or 20 per cent. of one turn, we at once perceive strong induced currents. These are positive for right-hand torsion, and negative for left-hand torsion. Thus we can not only produce induced currents, but, without changing the direction of the primary electric current, we can change the induced currents, making them positive or negative as we please; exactly as would occur if we rotated in opposite directions the small iron bars, placed side by side with the copper wire.

At this point it becomes important to know if these effects are produced by the twist given by torsion to the whole mass of the wire, or if each molecule turns separately and independently round its axis. There are many proofs that the latter view is correct. For, assuming the former, then, if an iron wire be twisted permanently by thirty or more entire turns, we should expect greatly increased effects as compared with those given by 10 or 20 per cent. of a single turn. But we find that after the first instant of torsion we have no increase of force in the current, even with a molar twist of 30 whole turns, which must of course produce a certain molecular twist; we find that the slightest torsion, say of 10 per cent. backwards, is sufficient to reverse the current, and thus more than neutralise the whole inclination which had been given to the molecules by the permanent torsion. Again, if, whilst the iron wire is under the influence of torsion, we bring near it one pole of a large natural magnet, laid in the direction of the wire, we find that the currents gradually diminish, until when the magnet touches the wire we at last produce zero. The polarised molecules, which under the influence of torsion lay at a certain angle with the axis, have thus been caused to rotate back again, and become parallel. Again, if we approach the same pole with the magnet at right angles to the wire, we find that the current gradually returns to zero (and therefore the molecules to parallelism) when the magnet is about two inches distant; but on bringing the magnet still nearer, they pass the zero point, now giving increased reversed currents, until they reach a maximum, when the magnet is close to the wire. We have thus rotated the molecules from their original angle of torsion, say of 45deg. to the right, through zero to 45deg. to the left. If this view is correct, we should expect that we might produce electric currents of reversed directions without the aid of any battery, by simply giving a to and fro torsion to the wire; and this proves to be the case. For we may join the telephone either to the exterior coil or to the simple circuit of the wire, and we shall then hear a sharp click at each movement of torsion to the right and left; thus imitating and reproducing all the effects which would be obtained by rotating a separate magnet through different angles of inclination with the wire.

There are many proofs which confirm this view*; but as the object of the author is to show the remarkable difference which exists between iron and steel in this respect, he will confine himself to showing the very great apparent rigidity of the molecules of tempered steel as compared with those of iron.

A very remarkable difference appears when we turn to tempered steel. For here we find that at certain degrees of temper (*e.g.* that known as blue or spring temper) there are only slight traces of molecular disturbance or rotation, no matter how many mechanical turns or twists we may put on the wire. In fact, the molecules here seem fixed and homogeneous throughout the mass. We have perfect molar elasticity, but no traces of rotation of one part over another—in other words, no molecular elasticity. Thus in iron we have an elasticity due solely to the freedom of molecular motion. In hard steel, on the contrary, we have but slight molecular freedom, with great molar elasticity, in which the separate molecules do not rotate separately, but all as one mass.

It is necessary to point out this difference of molar rigidity, as shown in tempered steel and in iron, because tempered steel is not the only form which thus differs in its mechanical and physical qualities from iron or soft steel. A similar difference is shown also by several known alloys of iron.

We can decrease the apparent rigidity of steel by the application of heat; for if we pass a constant and powerful current through the steel wire, which previously gave but feeble traces of rotation, and then heat this wire to red heat, a strong induced current is gradually produced. The current here has the power of rotating the polarised and heated molecules, and so giving out comparatively strong induced currents. But on cooling this wire it is impossible again to reduce it to silence. The molecules remain rigid, but at an angle to the axis. With iron, however, upon the application of heat under the same circumstances, we have a most violent rotation, which entirely disappears on cooling—proving again the great comparative freedom of its molecules.

We might believe that all the above effects in steel are due, not to the rotation of the molecules, but to the more or less retentive or "coercitive" force of steel with regard to permanent magnetism. But coercitive force, whilst it may suffice to explain, according to accepted views, the retention of magnetism, does not explain why we can produce positive and negative currents by right or left-handed torsions, nor why we should have induced currents by torsion. If we accept the term coercitive force as simply applicable to each molecule, then we have still to consider the greater freedom of motion of these molecules in iron than in steel. It is a general belief (which the author has hitherto shared) that the molecules of tempered steel have far greater coercitive force than those of iron. A simple experiment will, however, prove this not to be the case. For if we suppose that the molecules of iron turn with far greater freedom, it follows that they should also turn by the application of far less force. Now, if we take a soft iron and tempered steel wire, and place them at a given distance from a suspended

* "Molecular Magnetism," by Professor D. E. Hughes. *Proceeding* of the Royal Society, March 7-17, and May 10, 1881.

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magnetic needle, after finding them both to be free from magnetism, and we then magnetise these wires by drawing them over the poles of a natural magnet, then we may, no doubt, find as usual that the tempered steel has a far greater amount of remaining magnetism. But if, instead of this, we limit the reactive force of the natural magnet, by placing a piece of wood, say ½in. thick, between the magnet and the wire magnetised, thus limiting and controlling the force to any degree, according to the interval between the magnet and the wire to be magnetised, we then find, on magnetising these two wires with a weak reactive force, and again observing its action upon the needle, that the soft iron still shows powerful retentive or coercitive force, whilst the tempered steel has but feeble traces of magnetism, or none at all. Thus, contrary to the author's previous convictions, it appears that *iron possesses more coercitive force than steel whenever the inducing force is limited, and within the range of iron.*

If iron merely possessed greater coercitive force than steel, it would be impossible for us to employ soft iron in electro-magnets requiring quick changes of magnetism. But although in the previous experiment the remaining magnetism was far greater in the iron than steel, yet the magnetic force of the iron, whilst under the influence of the permanent magnet was some twenty times greater than its remaining magnetism; whilst with the steel there was but a slight difference in the force developed whilst it was under the feeble influence of the natural magnet, and when this was withdrawn.

Assuming the freedom of motion of the molecules to be greater in iron than steel, it occurred to the author that he should be able to free the soft iron from its remaining magnetism by simple vibration of the wire. This was found to be the case. An iron and steel wire are magnetised to saturation, or both may be given the same amount of permanent magnetism. We will suppose that they both deflect the suspended needle through 40deg. Now taking the steel wire and fastening one end in a brass vice, give its free end a slight pull to set it in vibration, it will be found that the steel has lost but 2deg., having still 38deg. of permanent magnetism, which cannot be further reduced by repeated vibrations. The instant, however, that a similar vibration is given to the soft iron wire, its remaining magnetism nearly all disappears; there is left at most 2deg., or in some cases only a trace. Thus the molecules are seen to be so comparatively free in iron that mere vibration will aid them in rotating. These two wires were again observed vibrating whilst under the influence of the permanent magnet. There was then a greater magnetic effect produced in the iron wire than previously; the vibrations aiding the rotations produced by the natural magnet.

The author was desirous to render visible this freedom of iron and rigidity of steel, so that these effects might be actually seen. For this purpose we may take three glass tubes, or ordinary phials, of any length or diameter, say 10 centimetres in length by 2 centimetres in diameter. If we now put iron filings in these tubes, leaving about one-third vacant, so as to allow complete freedom in the filings when shaken, we find that each tube, when magnetised, retains an equal amount of residual magnetism, and that this all disappears upon slightly shaking the tube; we are thus imitating the effects of vibration. But if in one of these tubes we pour melted resin (or in fact any slightly viscous liquid, such as petroleum, suffices) we then render these filings more rigid, and then we can no longer produce by shaking the disappearance of its residual magnetism. In pouring in petroleum we have apparently been introducing a strong coercitive force; but we know that it can only have the mechanical effect of rendering the iron filings less free to turn, and so comparatively rigid. If we desire to see the effect of torsion, we have only to shake the filings so that when the tube is held horizontal the vacant space is above, and rotate slightly (but without shaking) the tube containing the free filings about a horizontal axis. Its remaining magnetism instantly disappears upon rotation, although we evidently have not changed the longitudinal position of its particles. A similar effect takes place upon a soft iron wire, for if we magnetise it and observe its remaining magnetism, we find that upon giving a slight torsion to this wire, its remaining magnetism instantly disappears—a similar effect to that in the rotating tube of iron filings.

The author has remarked in these researches that in all alloys of iron the molecules are far more rigid than in the pure metal; and further that, with steel, tempering adds greatly to this rigidity. He is now engaged upon the question of the effect of different tempers on the same steel, and hopes in a future paper to be able to bring the results before the Institution.

Soft steel, when compared with hard drawn iron, shows that the mechanical hardening of iron has not in any great degree diminished its molecular freedom. Even the softest steel shows a high degree of molecular rigidity, as compared with the hardest iron, but far less than that of tempered steel. This would seem to indicate that steel in its softest state is still an alloy, though only feeble quantities of carbon may be held in that condition.

We thus perceive that a great physical change takes place in iron upon the slightest alloy with carbon; and that tempering produces this change in its highest degree. The writer, therefore, is strongly in favour of the view propounded long since, that steel when tempered is an alloy, containing fixed carbon in a far greater quantity than when soft. We know the physical properties of magnetic oxide of iron, of iron and tungsten, and of iron and sulphur. Now, in all these the writer has found that the iron loses its molecular freedom when even slightly alloyed. The physical results are, therefore, the same as those produced in tempering steel; and the induction balance thus indicates strongly that tempered steel shows the characteristics of a true alloy.

We could not have such a great physical difference between iron and steel, as above noticed, except by corresponding changes in its mechanical properties; and it is with a view of bringing out these relations in a discussion on this point that the author has ventured to bring his views before the Institution of Mechanical Engineers.

THE EASTERN TELEGRAPH COMPANY (LIMITED).

The twenty-first half-yearly ordinary general meeting of the Eastern Telegraph Company (Limited) was held on Thursday, January 25, 1883, at the City Terminus Hotel, Cannon-street, London, E.C., under the presidency of John Pender, Esq., M.P.

Mr. WELLS, acting for the secretary, read the notice convening the meeting, also the minutes of the last ordinary general meeting, and of the extraordinary general meeting held on the 3rd August last, which were signed by the chairman.

The report having been taken as read,

The CHAIRMAN said: I see that we have taken more than usual care to make the present report as full as possible. We have condensed a very great—a very large amount of matter into a very small compass, but I think it has placed our position before you in a manner that those who run may read [hear, hear]. However, before going more into detail, I think it is right that, as usual, I should draw your attention to what I call the ups and downs of our working during the last six months. Our revenue, as you observe, for the half year ended 30th September, 1882, amounted to £341,151, against, in the corresponding period of last year, £282,834, being an increase of £58,317. Analysing these figures, we find a very satisfactory growth of traffic throughout our system, with one or two exceptions. In the first place, the South African Company's dividend was at the rate of 8 per cent., instead of 10 per cent., being less by £3,900 than in the same period of 1881. There is, however, an increase of £900 in the receipts from the Black Sea Telegraph Company. The Indian traffic, on account of the crisis in Egypt, suffered very materially, but, thanks to our arrangement with the Indo-European Company, our receipts did not suffer. I will merely glance at the differences, for it is well you may carry them in your mind on this occasion, because the last half year has been altogether an eventful one. The ordinary expenses of the Company amounted to £69,809, against, in the corresponding period of 1831, £67,498, or an increase of £2,311. The main cause of this increase is our having opened four new stations—Athens, Karystos, Trieste, and Corfu. We have likewise had extra expenditure owing to the increased volume of traffic from Egypt and other places during the war. Repairs to cables amounted to £52,801, against £47,228, or an increase of £5,573. In abstract "C" you have the full details of this extra expenditure, and I may mention that this is an expenditure which will be always more or less fluctuating, as it arises very much from the circumstance whether we have many interruptions in our cable or are fortunate in being without them. The general expenses in London were £6,670. In the September half year of 1831 they were £6,521, or an increase of £149. In salaries there is an increase of £37. The office expenses show an increase of £161, rent and taxes an increase of £31—in fact there is only an increase of £278, but on the other hand there are decreases in other items of £129. These are the London expenses. The working expenses at stations in the September half of 1831 amounted to £47,418. In 1882 they amounted to £50,287. There are increases in these expenses of £3,522, and decreases of £653. The increase is caused, as I have said, by the four new stations which have been opened. The other expenses are of a very minor nature. The use of patents has cost us £2,750, the same as before, and the foreign agencies have cost us £1,339 against £1,198. There is an increase there of £141, being part expenses of a special agent who was sent to Constantinople. The other items are all very much the same. The directors' remuneration is the same; the auditors' remuneration is the same. The amount carried forward this half year is £56,836, against in the same period of 1881 £29,504, or an increase of £27,332, after paying a bonus of 1s. per share on the ordinary capital, making, with the previous payments, a return for the half year at the rate of 6 per cent. per annum [applause]. Our dividend as a rule at this time has been at the rate of 5 per cent., and at the end of the year we have given the bonus; but we felt so satisfied with our present position that we thought it well to give you a proportion of the bonus this half year, and I hope when I next see you we shall be able to confirm the dividend at the rate of 6 per cent. for the year.

When I had the pleasure of addressing you in July last, I referred to the state of our cables. We had at that time two breaks or interruptions in the Red Sea. We had one very important interruption in the Bay of Biscay, which had given us a very great deal of trouble. You all know what rough water that is; and we had to wait for favourable weather to be able to effect this repair. I am glad to say that it was accomplished, and the cable was picked up from 2,700 fathoms of water, showing clearly what I have very frequently stated

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at these meetings, that after all we have got a property. We can repair cables in the deepest water. It is expensive, I admit, but we can find where the fault is, and are able to repair the cable.

I then stated that we were in a peculiar position in regard to our ships. It was our duty to maintain, if possible, telegraphic communication between Egypt and England. It was important not only for our dividend, but equally important as regarded broad national interests, and I hold that the position we now occupy makes us—in fact, it is imperative on us that we should always consider those interests. Political as well as commercial interests are involved, and, therefore, while we benefit ourselves by maintaining our cables, we are very largely maintaining what I call great public interests. We went at this with a will. We brought our ship from the Red Sea, and left one of our cables there still faulty. We brought the "Chiltern" into the Mediterranean for two reasons. The first reason was, we knew that our land system was likely to be interrupted, and that the "Chiltern" would be more useful in the Mediterranean than in the Red Sea. Fortunately we did this. She was of the greatest possible use as you are aware, and her name has become generally known on account of the great services she rendered off Alexandria in maintaining telegraphic communication with Europe.

We also found our land lines being interrupted in Egypt. We were cut off from Port Said. It is true the Canal was open, but there was no communication unless through Turkey to Port Said. We saw that this was most undesirable. The traffic through the Canal is of immense importance to the shipowning interests of this country, and we thought it right to try and secure a communication along the Canal. We entered into negotiations with the Government. Those negotiations were more or less prolonged, as you know Government negotiations generally are; but we felt it was of the greatest possible importance to the public service, and also to the interests of this Company that we should be ahead of the Government in maintaining or in endeavouring to maintain our communications. We therefore resolved to take the ship that was at that time engaged in repairing the cable in the Bay of Biscay. We sent the ship out to Alexandria with sufficient cable to connect Alexandria with Port Said. We did not do that a day too soon. If we had waited till we had got the decision of the Government, I do not know what the consequences would have been. We, however, sent out the ship, and when the order was given to lay the cable we were in a position to do so at a few hours' notice. We laid the cable, and communication was opened between Port Said and Europe, and between Suez and India. We were enabled after great anxiety to obtain a land line. At first we could not make an arrangement with the Suez Canal Company, for reasons you may have read in the newspapers. This was owing to that venerable engineer who has gained a world-wide reputation, and I think he has been a great public benefactor; but still, when men have a strong bias about an enterprise of their own creating, they are apt to take views which are not so broad as they might have taken earlier, and we had great difficulty in getting our permanent communication along the Canal. Thanks, however, to the help of our Government, and to the broad views of the Khedive, we made an arrangement with the Suez Canal Company. In future we shall have an alternate line—a line along the Suez Canal connecting the Suez end with India, and the Port Said end with Egypt, so that we have two strings to our bow, if anything occurs in Egypt. This has been done at very considerable expense, but we were masters of the position. We availed ourselves of our position to do a great public good, but we also thought we should do good to the Company, and I am glad to say that we have secured a very important interest in favour of this Company. I doubt very much if what we have got will not give us pretty nearly full right to work the system that connects England with India without interference from any other parties. At all events, we shall do our work very badly if a second party comes alongside of us.

The last six months have been, perhaps, the most eventful period of this Company's history: but it is very satisfactory to know that, notwithstanding our ups and downs, notwithstanding the interruptions to our Indian traffic, we have had the largest returns this half year that we have had in any similar period of the Company's history. We have spent more money in the way of expenses than we have done before, but, notwithstanding this great expenditure, we have gained, through the active telegraphic communication carried on by the Government and the Press between the seat of war and Europe, a return which amply repays us, and we have given accommodation which I hope will be appreciated by the general public as it has been by the Government, for I may say that we have received from the Government, besides what I have mentioned as material benefit, a letter thanking the Board and those who have carried out this work for the public spirit displayed in very peculiar and extraordinary circumstances.

Now, a company like this (as I remember a gentleman that I see before me remarked) cannot stand still. We must either go forward, and go forward in these days of progress at a very considerable pace, or go backward.

I have alluded to our South African traffic, and, as we have found that it was a valuable traffic, it could not be placed in any degree in a secondary position. The cable, as you know, goes from Aden to Zanzibar, and on to Durban. Up to Aden we have to carry not only the Indian, Colonial, and Chinese traffic, but also our South African traffic. It was impossible to make the service what we desired it should always be, and, therefore, we had no hesitation in at once making arrangements to lay down an additional cable from Suez to Aden, so as to maintain that traffic in the efficient state we think it ought to be in. We did this also from the knowledge that the Red Sea was virtually in the future to be a sea for our cables, and, therefore, we did not hesitate to carry out what has been referred to in the report—contracting for and laying a cable between those two points, and we have no doubt we shall get a very good return from that outlay. We have also during the six months carried out a concession we had from the Turkish Government of laying a cable from Malta to Tripoli. That has been done, and successfully done, and I believe that will be an additional source of revenue to the Company.

Now, gentlemen, notwithstanding all this expenditure, in which, I believe, we have served the shareholders and general public, I believe we have given satisfaction to our Indian, China, the Cape, and our Australian customers.

I am glad to say that, as I have said, we are able to-day to put a very fair and satisfactory balance-sheet before you. I feel that we have placed our system, as a system of telegraphic communication, in a position that it would be very difficult to beat. There is scarcely any great commercial point in the world that we have not reached by telegraphy. We have not gone on by leaps and bounds with our dividend, but we have enormously strengthened and improved the value of our property by what we have done.

I hope the result will be that we have a system so very nearly completion that we shall look back on it with satisfaction, as having derived benefit from that particular progressive policy I have referred to.

I think I have now pretty well exhausted all my notes. There is a reference in the report to the bonus which we gave to our people employed in Egypt. If you throw your mind back to the last half-yearly meeting, you will remember there was a very strong expression of opinion and sympathy with our young men who were employed during the war. In fact, there was a resolution passed thanking them for their services. Now we felt, looking at the sacrifice they had made—looking at the losses many of them had sustained—(everything except what they had on their backs)—that in the midst of our prosperity, and having done very well for all parties, we thought it would be wrong to leave them out. Therefore we have given them it is not a large sum to each—a bonus that will satisfy them, and which will not in any way interfere with what you will receive. It will give them something more than a mere formal resolution, for it is a substantial acknowledgment from you of what they have gone through. It will also incite them to similar exertions in the future in your interests should occasion arise. Now, with these remarks, I beg to move,

"That the report and accounts of the directors to the 30th September, 1882, submitted to this meeting be, and they are hereby received and adopted."

The VICE-CHAIRMAN (the Marquis of Tweeddale): I beg to second that.

The CHAIRMAN: That has been moved by myself and seconded by the Marquis of Tweeddale, and if any gentleman in the room has any remark to make, I shall be very glad to answer the questions before I put the resolution to the meeting.

Mr. LANDELL: There is just one point I should like to touch upon. I see by the balance-sheet that there are debentures repayable this year to the amount of £232,000. I should be glad to know at what rate the directors will be able to replace those debentures. They were issued at 6 per cent., which was not an extravagant rate at the time, but as they mature I hope that we shall be able to replace them as they fall due at a less rate than they were formerly issued at.

Mr. WILLIAM ABBOTT: I see in one paragraph of the report that you intend to take a large proportion of the money necessary for these new cables from the reserve fund. I do hope that you will take an early opportunity to replace that money. It is clearly a capital charge that ought to be replaced. In the present flourishing condition of the Company our reserve fund is really not required. Not that I intend to take a gloomy view at all, but a time may come when it may be a very desirable fund to draw upon; and it was for the special purpose of an accident that that fund was created. I can see that if you sell any portion of the stocks you hold you can do so at a considerable premium, and I, therefore, commend you for the wisdom which you have displayed in making such an admirable selection as you have done.

You have referred to a special allowance having been made to the Egyptian staff. You made that payment to them on your own responsibility, but I dare say you come before us to endorse that act. I do not think there is any one shareholder in this room or on the list of the proprietors who would take exception to the course which you have adopted. I should like to go further. In my experience of companies I have never interfered with boards of directors as to what they do with regard to their staffs, as I consider it is for directors to take the full responsibility for what they do. But, at the same time, directors like sometimes to be fortified by the views of a meeting. I know the extraordinary work which was thrown on the London staff during that period of excitement and anxiety, from the effects of which the directors themselves were not free, and I think it would be very right on this occasion to go outside the principle of non-interference and express our opinion, conveying not merely thanks but something substantial to the London staff. So far from detracting from what the Egyptian staff have done, I would say that I think they have done wonderfully, and that it is to their zeal, foresight, and ability that you are indebted for this magnificent balance-sheet. At the same time, in addition to the vote of thanks passed to the staff in London, we should carry with it a substantial expression of our opinion in the form of a money bonus. I am not too old to remember the feeling of veneration that I had for the directors of the London and Westminster Bank when they proposed, after paying 10 per cent. to their proprietors, to give a bonus to their staff. I have no doubt of the good that it would be to adopt such a suggestion as that which I now recommend.

The CHAIRMAN: With regard to the debentures, I think I have always stated, more particularly twelve months ago, when we were discussing the question of finance, I was hopeful of dealing with that question. I may say, too, that I am hopeful to-day, as the Bank rate is going in the right direction.

Mr. ABBOTT: It is down to 4 per cent.

The CHAIRMAN: You may depend upon it that that matter will have our very careful study. We should have acted before this but for the high rate of interest prevailing. Had the Bank rate been at a low rate, we should, I believe, have been dealing with the debentures before now, but we are waiting for the proper time to deal with them. When it comes we shall look very carefully to getting our debentures placed at the lowest rate.

In regard to the remarks of Mr. Abbott, I entirely concur with him. I like to see a very fine substantial reserve fund. I am strongly in favour of it, and if we should take any portion from our reserve fund at any time, I hope it will be replaced. I have an idea that we ought to put £100,000 a year to the reserve fund, and we should get it up to a large sum in a short time in that way. If we can keep down capital expenditure, which I think it is very desirable to do, and carry out the necessary additions that are required by taking a little from the reserve fund, I think we meet the wishes generally of the shareholders. These are questions which always receive from us very serious attention, and on these occasions, when we give you a full and explicit account of all our doings, we are always glad to receive suggestions such as Mr. Abbott and the other gentleman have made. We have the very best information ourselves, but the more information we get the better. We are always prepared to receive it.

I am very much pleased at the expression of opinion, so marked as I gather

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it to-day, from this meeting in favour of our staff. The staff have done their duty well and faithfully, and at the same time I am bound to say that those who have been controlling the staff have had no easy work. It was not only daily work when this crisis was going on—it was hourly work—night and morning, and constant and steady attention was required. The communications that were coming required immediate and prompt attention, and as an evidence of great enterprise I may mention that we actually chartered two ships during that great crisis, so that nothing should be wanting. We chartered them at very considerable expense. But you have had your return in a larger degree than what you paid for them. Telegraphy is not an ordinary business, but one requiring attention every hour of the day, and it does receive that attention from us. If not I should not be able to address you as I do to-day. I am, therefore, very much pleased at finding that the action of our staff has been appreciated, and you may depend upon it that the directors will give due attention to your views in this matter. The resolution I have now to put—

Mr. JOHN NEWTON: It does not seem that the salaries and wages have been much increased though your staff has been so hard at work. The expression of opinion of the meeting is that something extra should be given, that the extraordinary work of the past half year should be recognised, but I think that whenever the staff is extraordinarily pressed they should receive some special attention.

The CHAIRMAN: I quite understand the position and what you say, and I am very glad to see that you take the same view as Mr. Abbott does. You may depend upon it that we have a very good staff, and the staff know that they have very good employment, and they know the value of their employment as much as we do. It is encouraging when some appreciation of the staff is shown, and you may depend upon it that we who represent you will act in accordance with your views. Now, gentlemen, those in favour of the motion hold up their hands. To the contrary? Carried unanimously. The next duty that I have to perform is to move—

"That Lord Sackville Cecil, who now retires, be and is hereby re-elected a director of the Company."

Mr. G. G. NICOL: I beg to second it.

The resolution was put to the meeting, and carried unanimously.

Lord S. CECIL: I am very much obliged to you, and I hope I shall continue to deserve your confidence.

The CHAIRMAN: The next resolution is—

"That General Lord Alfred Paget, who now retires, be and is hereby re-elected a director of this Company."

Sir JAMES ANDERSON: I have much pleasure in seconding that.

The CHAIRMAN put it to the meeting, and declared it carried unanimously.

General Lord ALFRED PAGET: I beg to thank you also. I hope in the course of two or three months to be able to go out and see a good many of our officials in our Eastern districts and in the Mediterranean, where I went last year. It always does good when they see directors taking an active interest in the affairs of the Company.

A SHAREHOLDER: The next resolution on the agenda paper has reference to the election of auditors. With your permission I shall have much pleasure in moving—

"That Mr. Henry Dever and the firm of Messrs. Quilter, Ball, Crosbie, Glegg, and Welton be and they are hereby elected auditors of the Company for the current year with a joint remuneration of £100."

Mr. JOHN NEWTON: I second that.

The CHAIRMAN put it to the meeting, and declared it carried.

Mr. RIXON: I may say one word more. We have not spoken about the remuneration of the directors. Has not the time arrived when that may be increased?

The CHAIRMAN: That concludes the business.

Mr. ABBOTT: I presume that your modesty prevents your touching upon that subject, but I have not the slightest doubt that the time will come when a resolution such as that just foreshadowed will be received and adopted. I well remember in the early period of the Company's history—as I think I have said before—that there was no better abused man than yourself. The proposals that you brought forward for the extension of capital were met by counter resolutions, and the stormy scenes we had in connection with this Company ought to be well remembered. All the advice that you as a Board have given this Company has proved perfectly correct. I well remember the proposals as to the Black Sea line and the South African Company. Look at what those measures have resulted in. We were told that we were heaping up debentures. Well, look at the result. I have always maintained that a telegraph company, like a railway company, cannot stop still so long as the world moves on. I may here say I will undertake at the next meeting—now when we have dealt with the staff—I shall undertake to propose at the next meeting an increased remuneration to the Board. With these remarks I beg to move that you be thanked for what you have done for the shareholders at a time of extraordinary trial and anxiety.

A SHAREHOLDER seconded the motion, and

Mr. ABBOTT submitted it to the meeting.

Mr. MOORE: In speaking of this matter of the directors, I think it affords me a little opening to touch on a question not dealt with in the report—and one which could not well be, as not being one of figures, but as relating to the general working of the Company. I have listened to your speech with a great deal of interest, but there is a matter that some shareholders would like an explanation of. Our managing director, Sir James Anderson, is at the present moment the chairman of a news agency—the Exchange—and that company was started at the time when the Egyptian war was carried on ["Time, time"]. Sir James Anderson is competing with the best customers that you have in that way. I hope you will allow me to say these few words, as it will give you an opportunity of saying yes or no to them. It is a question for the shareholders' interests.

The CHAIRMAN (interposing): Let me ask you one question. Are you connected with the Central News?

Mr. MOORE: I am a journalist.

The CHAIRMAN: I want fair play in this. This is a question that will in all probability come before the courts. This meeting, therefore, is not the proper place to discuss it. I think it would be very improper to do so. I know perfectly well what you are going to arrive at.

Mr. MOORE: I think not.

The CHAIRMAN: I wish to say that I am as anxious as you are that this question, if you have a case at all—for I presume you are representing that—I am as anxious as you are that it should be inquired into, but let it be done at the proper place. This is not the place to do it. I am quite prepared to say that the imputations thrown on this Company from certain quarters we treat with the utmost contempt. We stand too high to feel in any degree such imputations. We have done the service in a way that it would be impossible to do it better. I speak generally, and the more the question is investigated the more will be seen the importance of our position. I speak with all proper respect for you in saying this. I will take care of this, that whatever there may be between the two companies—I do not care if there is one or a dozen companies—they shall all get fair play. That is all I have to say as chairman of the Company. I am perfectly prepared from what I know of the case to stand by the side of Sir James Anderson, and to vindicate him.

Mr. MOORE: May I ask one question? Is it true that our clerks acted as correspondents for the Exchange Company?

The CHAIRMAN: It is not true, I can answer that.

A SHAREHOLDER: I beg to move a cordial vote of thanks to the gentleman to whom we are so greatly indebted—Sir James Anderson. No man has served you better in this business in Egypt than Sir James Anderson, and every one present I am sure will join me in conveying a vote of thanks to him. When the time comes no one will be better able to defend himself in this matter than Sir James Anderson.

Major LESLIE: I second this resolution. I represent the largest interest in the Company. I am constantly watching its operations, for I represent over £100,000. I have no personal relations or interests with Sir James and the other directors, only those of business. I utterly disbelieve that anything wrong has been done by Sir James Anderson, or anything that an honourable gentleman might not do. I refuse to believe it. I have great pleasure in seconding the motion.

The CHAIRMAN put the motion, and declared it carried unanimously, with one exception—Mr. Moore.

Mr. WELLS (to Mr. Moore): What is your name?

Mr. MOORE: My name is Moore.

A SHAREHOLDER: Let us hear you no more.

Mr. MOORE: You will have me every time——

The CHAIRMAN: I am very much obliged to you for what you have said. I can assure you, as shareholders generally with myself, that we are entirely satisfied with the position we hold. It is not strictly pecuniary interests that we look to, but to the important work we have to perform, and the great national interests the Company serves. At the same time, I have always been an advocate for paying gentlemen well, and when the Company arrives at the position that it can pay very well, I shall be ready to agree to a proposal to increase our remuneration. At present we are very well satisfied.

Mr. WELLS (to Mr. Moore): What shares do you hold?

Mr. MOORE: You will find in your book.

Mr. WELLS: What is your initial?

Mr. MOORE: J.

The meeting then separated.

THE CUBA SUBMARINE TELEGRAPH COMPANY (LIMITED).

The twenty-third ordinary general meeting of the shareholders was held at the offices of the Company, No. 61, Old Broad-street, on Wednesday, the 31st January, Mr. Joaquin de Mancha, the chairman, presiding.

The SECRETARY (Mr. James Scott) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, will you have the report read first, or will you take it as read? [Voices: "Take it as read."] Well, gentlemen, the accounts have been before you for several days, and as we rather pride ourselves that our accounts are very clear and explicit, they do not require much explanation from me. You will see that our late chairman (Mr. Thomas Hughes) has resigned his position at the Board, and we regret his loss very much. The ability and experience that he had will rather cast me in the shade, but I can only say that I will do my best to conduct the business of the Company in the same way that it has been conducted, and if there should be any shortcomings, I must throw myself on your generosity to overlook anything that is not quite up to the mark [applause]. The accounts, as you will see, gentlemen, show that after providing for the Preference dividend of 10 per cent. we have been able to recommend that a dividend of 7 per cent. on the Ordinary shares shall be paid to you. I think, taking all things together, you must consider that satisfactory [applause]. We shall divide for the year 7½ per cent., and, looking at the accounts, you will see that besides doing that we have been able to place to the reserve fund the sum of £1,325 more. Some gentlemen may perhaps think that the reserve fund is getting too high, but for my own part I should like to see it much higher [applause]. The business of a telegraph company is so very uncertain, we are subject to so many casualties and unforeseen events, that I think the stronger the reserve fund is the more satisfactory it will be for the shareholders, and you may reckon that the dividend on the Ordinary shares will not be dimished so long as we have sufficient funds for any repairs which may have to be done. The business of the Company, I am happy to say, has been very prosperous during the year. We have earned nearly £5,000 more than we did in the previous year [applause], and I think, taking into account the little business that has been doing all over the world, we cannot complain, seeing that we have got a very substantial increase on our profits. I am sorry to say the cash does not come in in quite the same proportion as the increase in the number of telegrams. We have had nearly 5,000 messages more, and we generally reckon that every telegram produces nearly £1. In consequence, however, I suppose, of people being more experienced in telegraphing and in curtailing their messages, we have not increased so much in point of money as in the number of messages. At all events, I think we cannot complain of the want of success of the Company, and, with these few remarks, I will conclude by proposing "That the report of the directors and the accounts be received and adopted." If any of

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the shareholders have any questions to ask I shall be happy to answer them to the best of my ability [applause].

Mr. ALEXANDER F. LOW seconded the resolution.

The resolution was then put and carried without comment.

The CHAIRMAN next proposed that a dividend of 7 per cent., free from income-tax, on the Ordinary shares be paid. The dividend warrants were all ready, and would be posted to-night, so that there would be no loss of time in their getting the dividend. He also proposed that 10 per cent., subject to income-tax, on the Preference shares should be paid at the same time.

Mr. LOW seconded the resolution, which was also agreed to *nem. con.*

The CHAIRMAN: Well, gentlemen, that is the whole of the business that you are called here to-day for.

Mr. GRIFFITHS: Mr. Chairman and gentlemen, I think we ought not to separate without placing upon record our appreciation of the services which had been rendered to this Company by Mr. Hughes who, we are glad, has received promotion, though we regret that we lose by what he has gained. He has been connected with the Company from the beginning. He is, undoubtedly, a man of considerable intelligence, clear and acute judgment, of comprehensive understanding, and of a most gentlemanly bearing. He has presided over us in times of prosperity and in times of adversity, and I think we may say, without dispute, we have been fortunate in having at our head a gentleman who had a legal training, and who was enabled to bring those qualities to the service of the Company with which he was connected. Our Company, as you are aware, has extensive foreign business transactions, and the knowledge of international law which he possessed must have considerably facilitated the transaction of the business with the Spanish Government and the Island of Cuba. You yourselves have witnessed the way in which he presided, and I think you must acknowledge that he conducted the proceedings with fairness, that the discussions were complete, and the information was given readily and kindly [applause]. Of course, as I said before, that which is his gain is to a great extent our loss. The speaker continued that by that remark he did not cast the least reflection on the present directors. They were gentlemen of experience, but it is always a bad thing for a company when the leading man—that is, the chairman—leaves it. He thought, therefore, they would agree with him that it was a proper thing that they should express their sense of the benefit which the Company had received from his presidency, and that they should also express their hope that those great qualities which had been of such service to them would, hereafter, be of service to others in a wider sphere, and he would not only have the satisfaction of remembering that he had been successful as chairman of a telegraph company, but also as one of the members of the judicial establishment of this great country [applause].

Mr. NEWTON said he had great pleasure in seconding the proposition moved by Mr. Griffiths.

Some little discussion then ensued amongst the shareholders as to the desirability of adding some tangible mark of the shareholders' appreciation. The result was that the shareholders empowered the Board to expend the sum of 100 guineas in the purchase of a piece of plate to be presented to Mr. Hughes.

A vote of thanks to the chairman and directors closed the proceedings.

THE ELECTRO-AMALGAMATOR COMPANY (LIMITED).

The first general (statutory) meeting of the shareholders of this Company was held at the Terminus Hotel, adjoining London Bridge Station, on the 26th ult., under the presidency of Mr. W. J. Tanner.

The CHAIRMAN having described the amount of work which had been done since the formation of the Company in getting the business in order for practically treating quantities of ore, by erecting a gas engine, crushing machine, riffle table, dynamo machine, and by transacting various other necessary matters, said: I will now, gentlemen, say a few words as to the patent itself. When the Company was formed we had a conference with Mr. Aston, Q.C., in order to settle the final specification, and as it was vacation time we were fortunate enough in having an unusually long consultation, and, after going into the matter fully, Mr. Aston was perfectly satisfied as to the validity of the patent, subject to its not having been anticipated—a matter to which we have given our full attention by having the Patent Office thoroughly searched. One of the chief charms about this patent is its simplicity, which consists of the application of well known agencies for a particular purpose, and in a particular manner, which can be adopted at a remarkably small cost. From a scientific point of view the invention must carry out the objects for which it is intended, and from the scraps of knowledge I have been able to patch together I think I shall be able to show you some strong evidence in support of the principle. I must remind you that I am neither an electrician, chemist, nor a mechanic, and, therefore, my remarks and opinions must be taken for what they are worth; but it seems to me there are so many diversities of opinion and so many theories about the properties and effect of electricity, that it is impossible to arrive at any conclusion that is altogether satisfactory. As far as I understand the matter, it is simply this. Let it be given as an admitted fact that mercury, when fresh and clean, readily absorbs gold and silver when they come in contact with it. It must be also allowed that the presence of antimony, arsenic, mundic, titanic sand, and various other substances, sicken or coat over the mercury, and so prevent gold and silver from adhering or amalgamating with it; and as there are vast quantities of ores with gold and silver all over the world that contain some one or more of these minerals, which are destructive to the mercury, it is obvious that any system that can be invented which will keep the mercury clean and bright, and always ready to take in the gold and silver, must be of immense value. That Barker's electro-amalgamator carries out this requirement is conclusively proved, both in theory and practice. Now, in the case of this invention the negative pole is applied to the mercury, and as mercury is a very good conductor of electricity, it, in fact, becomes our negative pole or cathode. The positive poles are strips or wires of copper or some good conductor, which are laid over but not touching the mercury. Just as the electric light is formed by making a break in the circuit and introducing carbon points, so our circuit is broken and joined, so to speak, by the agency of water; the water becomes chemically changed, and, of course, if chemical matters are introduced into this water, various other changes and modifications will take place. The first thing that strikes our notice on the application of the electricity is the immediate disappearance of any scum on the top of the mercury—it becomes as bright as it possibly can be. As the various substances that usually sicken it come under the influence of the electricity, they are immediately rejected, and the surface is kept constantly bright and in the fittest state for absorbing gold. This is conclusively proved by artificially sickening the mercury; directly the electricity is applied the matter that sickened the mercury is ejected, and the tiny globules into which it has been beaten run together, presenting a bright and uniform surface. Now, gentlemen, I think it logically follows, if the electricity will purify the mercury when sick, it will *a fortiori* prevent it from getting sick when pure. The invention in this respect is of enormous value, but I contend that the keeping the mercury clean is not the only point gained, and I think it will be admitted that the electricity induces the contact between the gold and silver and the mercury. In this way certain minerals are driven by diamagnetic action from the positive to the negative pole, and among them gold and silver. Now, as the crushed ore passes over the mercury it is conveyed by means of the water between the negative and positive poles, and each gold particle becomes an electrode, with the obvious effect that it is impelled from the positive to the negative pole. In our case the negative pole is clean mercury, which readily absorbs the gold and silver particles, so we have not only the natural gravitation of the gold but the diamagnetic force, which, I think, possibly precipitates the gold in the mercury, leaving it clean at the top. Why, it may be asked, are not other metals like iron and copper equally by the same influence driven to the mercury? So I say they are, but as mercury has no affinity for these metals they are kept moving over the mercury, getting as far as possible from their enemy, the positive pole, until they are thankfully washed away by the water. In the case of sulphurets the action is different. They become decomposed, and thus liberate the gold, and instead of depositing themselves on the negative pole and sickening it, they judiciously avoid it, and go to the positive pole, attracted by the copper, and get formed into sulphate of copper. It is more than satisfactory to find these theories are practically proved true, for if you refer to pages 10 and 11 on our pamphlet which has just been issued, you will see that out of some sand given to us from one of the Indian mines, assaying 2oz. 13dwts. to the ton, by the Electro-Amalgamator process we have taken out 2oz. 11dwts. Now the analysis of this sand shows nearly 61 per cent. of titanic acid and iron, so there can be no wonder that with the ordinary process the gold could not be extracted. I understand there are thousands of tons of this sand, and the result we have shown with our treatment is worth £50,000 a year to the owners of this property. This is not an isolated instance, but from the information I can gather it forms an example of the rule, and by no means an exception. Indeed, I can assure you, gentlemen, I am bewildered at the possible value to the world at large of this invention. From all quarters I hear of the thousands of tons of gold and silver ores that are unworkable from the presence of the obstacles which this invention removes. There are generally two values to saleable property, first, its intrinsic value, and secondly, what you can get for it. Now, this invention being all that is claimed for it, its intrinsic value is many millions, but this we cannot expect to get, except, perhaps, indirectly. A person came to me some months ago with the view of purchasing one of the patents. I told him we were not ready, and before the invention was made public we wished to prove it and perfect it on a commercial scale. He said, "You take my advice, if it is really good, and will bear looking into, do not be in a hurry to part with it; if it is worth nothing, sell it at once." Now, there is a sublime simplicity about this system of financing that, I fear, is more remarkable for its success than its morality. We, as directors of this Company, have not only your interests to protect, but our names, and, therefore, we must take personal care that any patent we offer for sale will bear looking into, as there is no consideration sufficiently large to induce us to foist anything upon the public unless we are clearly satisfied it is all we claim for it. I do not see that we attack any vested interests; on the contrary, the vast amount of capital invested in gold and silver mines that do not pay will now return profits, and those mines that do pay will pay more. All we require now is gradual publicity, and in this, I am sure, you will help us. I say gradual, as, owing to the small space at the works, there is not room to have a large assemblage at a time, but both scientific and practical men who have seen the invention have always expressed themselves as strongly impressed with its value. We must, however, make it generally appreciated before we can expect to sell any of the patents at anything like their actual worth. I am very much obliged for the kind way in which you have listened to my remarks, and I shall be happy to answer any questions to the best of my ability, but I am not prepared to join issue where any scientific principles are involved.

A discussion followed, and in reply to questions and observations,

The CHAIRMAN stated that they had no negotiations on foot at the present time for the sale of any of the patents, as it had only been within the last few days that they had attempted to make the matter public, but they were ready to commence negotiations almost immediately. They had been in correspondence with several of the Indian mining companies. Several of the directors of those companies had called on them, and had expressed very much interest in the patent, and having the patent in hand. India would be their first field. The capital subscribed in cash had been £5,000, of which £2,500 had been paid up. The patentee had received £1,000. There was, roughly, about £500 or £600 at their bankers. The remaining £800 or £900 had been expended in rent, a dynamo machine, and a gas engine. In all probability the whole of the capital would have to be called up. [A VOICE: I hope so.] The amount of profit would be distributed in proportion to the amount paid up.

Two or three shareholders expressed their opinion that the profit should be distributed per share, not according to the amount paid up.

The CHAIRMAN, continuing, stated that the point would be made perfectly clear to the shareholders before anything was decided. His own opinion, however, was that in dividing profits the distribution should be made according to the amount paid up. As he had said, the capital would probably all be called up. It would be required for obtaining the patents.

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They had bought half the patents from Mr. Barker on these terms, excepting the American, which was left in abeyance for the time, and excepting the New Zealand patent altogether, but the whole of the rest of the patents all over the world. They had paid for their half £4,000 in shares and £1,200 in cash, and when the American patent was received they would pay another £3,000 in shares and £1,800 in cash. Altogether that made £10,000 which the patentee would receive—£7,000 in fully paid shares, and £3,000 in cash. The capital of the company was £20,000, of which £5,000 had been offered for subscription, which had been more than applied for. He could not say that they were yet in a position to enter into negotiations for the sale of a patent. Their policy to a great extent was to build up their foundation sufficiently strong and so secure that they might be able to sell. They had fourteen years for the patents to run. He felt that if they were to force the sale of any of their patents they would be greatly prejudiced. They had received the patents for France, India, Canada, and Portugal. Those for Spain, Germany, and United States were going through, and that for South Australia they could not yet have got. As to Chili, Peru, and the Brazils, they had special agents who were taking the patents through.

The following resolution, on the motion of Mr. H. B. HEWITT, seconded by Mr. C. RANDOLPH, was then passed with one dissentient:—"That the remuneration of the directors for the ensuing year be 5 per cent. of the amount of profits actually divided during that period."

[We are requested to state that:—"Since the meeting the directors have received the results of some washing of ore from, perhaps, the richest gold mine in the world, the quartz from which shows by assay 44oz. gold to the ton; but, owing to the refractory nature of the ore, sufficient gold in paying quantities has not yet been obtained. Mr. Fred Claudet's assay shows that Mr. Barker's process has extracted 38oz. out of the 44, or about £130 per ton."]

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED).

The poll demanded at the meeting of this Company (held on the 23rd ult.) was taken last Tuesday, between two and five o'clock, at the City Terminus Hotel. It will be remembered that at the meeting on the 23rd ult. the chairman (Sir H. W. Tyler, M.P.) moved the adoption of the report, and that Mr. Gillitt subsequently brought forward an amendment for the appointment of a committee of the shareholders to inquire into and report upon the position and conduct of the affairs of the Corporation. On the show of hands there was a decided majority in favour of the amendment, when a poll was demanded on behalf of the directors. At the close of the poll,

Sir H. W. TYLER, M.P., moved the further adjournment of the meeting to Monday next, at the City Terminus Hotel, at twelve o'clock, "for the purpose of receiving the report of the scrutineers and the declaration of the poll and of continuing and concluding the business."

Mr. LANE-FOX seconded the motion, which was carried.

Mr. JOSEPH BRAITHWAITE then observed that it might be interesting to the shareholders to know that on the face of it the poll showed a large majority in favour of the directors.

It may be added that the remaining business after the disposal of the report is the confirmation of the appointment as a director of Lord C. J. Hamilton, M.P., in the place of Mr. Nettlefold resigned, and the re-election of the retiring directors and auditor. A resolution will also be proposed, enabling a further issue of 700 fully paid £10 shares to Mr. C. F. Brush or his nominees "in compromise of the agreements for the purchase of the Russian and Belgian patents."

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).

Report of the directors to the ordinary general half-yearly meeting of the proprietors, to be held at the City Terminus Hotel, Cannon-street, London, on Friday, the 9th inst. at noon. The total receipts from the 1st July to the 31st December, 1882, including a balance of £5,583 19s. 9d. brought forward from the last account, amount to £262,534 0s. 2d. The traffic receipts show an increase of £36,026, as compared with the corresponding period of last year. The total expenses of the half year, including repair of cables, income-tax, &c., as shown by the revenue account, amount to £58,084 18s. 8d. The directors, under the powers conferred upon them by the Articles of Association, have, before declaring the net profits, set apart the sum of £75,000 to the renewal fund, leaving an available balance of £129,449 1s. 6d. Interim dividends of 15s. per cent. on the Ordinary Stock and 30s. per cent. on the Preferred Ordinary Stock, free of income-tax, were paid on the 1st November last, absorbing £52,500, leaving a balance of £76,949 1s. 6d., out of which the directors recommend the proprietors to declare final dividends, free of income-tax, of £1 per cent. on the Ordinary Stock, and £2 per cent. on the Preferred Ordinary Stock, amounting to £70,000, and making a total distribution for the year ended the 31st December, 1882, of 2¾ per cent. upon the Ordinary Stock, and 5½ per cent. upon the Preferred Ordinary Stock, leaving a balance of £6,949 1s. 6d. to be carried forward to the next account. The Brest-St. Pierre cable, laid in 1869, which was broken in mid-ocean on March 18 last, was successfully repaired on Sept. 20. Four faults were removed, in depths varying from 400 to 2,000 fathoms of water. The ship employed upon the repairs of this cable in deep water was the Telegraph Construction and Maintenance Company's steamship "Scotia," which was engaged upon the work for more than four months, at a cost, including new cable used, of upwards of £90,000; the directors consider that the expenditure of so large a sum of money is amply justified by the results, the electrical condition of the cable being now perfect. The cost of these repairs has been charged to the renewal fund. The Company's repairing steamship "Minia" has been engaged during the half year in repairing a fault in the Brest-St. Pierre cable, which occurred on the 25th July, at a distance of 200 miles from St. Pierre, and also in repairing the St. Pierre-Duxbury cable, which was broken on the 26th September. The Company's system of cables and land lines on both sides the Atlantic is now in good working order and condition. The tariff of 2s. per word, which was resumed on the 22nd May last, upon the execution of the joint purse agreement with the American Telegraph and Cable Co., has proved satisfactory. Although no competing Atlantic cable schemes have actually been established within the last half year, two were before the public for several months. The eight cables now at work are more than enough to meet every possible requirement, and the directors trust that by keeping up the present prompt and efficient service, at the moderate rates now charged, the public will be deterred from subscribing money to new cable enterprises, which cannot, under any circumstances, pay a dividend equivalent to the great risks incurred. The directors regret to announce that Mr. L. M. Rate has resigned his seat at the Board. His long experience in connection with Atlantic cables, as chairman of the Atlantic Telegraph Company and director of this Company, rendered his services of great value to the Board. Mr. William S. Cunard has been chosen to fill the vacancy caused by Mr. Rate's resignation. In accordance with the Articles of Association, two directors of the Company, the Marquis of Tweeddale and Mr. Cyrus W. Field, retire at this meeting, and, being eligible, offer themselves for re-election. Mr. Joshua Dean and Mr. Francis Glass, the auditors, also retire, and offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

Companies.	Closing Prices Jan. 31.		Business Done Week Ending Jan. 31. Highest.		Lowest.
Anglo-American	50,	51	50½		50
Do. Preferred	81½,	82½	82½		81½
Do. Deferred	18,	19	18¾		18½
Brazil Submarine	12,	12½	12½		12
Cuba	10,	10½	10 3-16		10 3-16
Do. Preference	17,	18	—		—
Direct Spanish	6½,	6¾	—		—
Do. Preference	16,	17	—		—
Direct United States Cable	11½,	12	12½		12
Eastern Telegraph	10¾,	11¼	11⅛		10¾
Do. 6 per Cent. Preference	13½,	13¾	—		—
Do. 5 per Cent. Debentures, 1899	105,	108	—		—
Eastern Extension	11½,	11¾	12 1-16		11¾
German Union	10,	10½	10½		10¼
Globe Telegraph and Trust Company.	6¾,	6¾	6⅝		6 7-16
Do. Preference	12⅝,	12¾	12¾		12½
Great Northern	12,	12¼	12 13-16		12¼
Indo-European	32,	33	—		—
Mediterranean Extension	1½,	2	—		—
Do. Preference	6,	8	6½		6¼
Reuter's	10½,	11	—		—
Submarine	252,	257	252		252
West India and Panama	1½,	1¾	1⅝		1¾
Do. 1st Preference	7,	7½	7½		7¼
Western Brazilian	7¼,	8	8		7¾
West. Union 7 per Cent. 1st Mortgage	122,	126	—		—
Do. 6 per Cent. Sterling Bonds	102,	105	104½		104

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¼	—		—
Oriental	⅝,	¾	13-16		¾
United Telephone	10¾,	11¼	11⅛		10½

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	5½,	6½	6⅝		5 11-16
Do. (fully paid)	10½,	11½	11⅞		10
Hammond Light	3½,	3¾	3 15-16		3
Eastern Electric (£4 paid)	1,	—	—		—
Pilsen, Joel, and General Electric	¼,	1	13-16		⅝
Swan	2⅛,	2⅜	2⅜		2 1-16
Maxim-Weston	¼,	½	⅝		5-16

TRAFFIC RECEIPTS FOR DECEMBER, 1882.

Companies.	Dec., 1882.	Dec., 1881.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,600	2,741		—
Direct Spanish Telegraph Company	1,346	1,458	—	112
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Eastern Telegraph Company	49,610	49,84	—	234
Great Northern Telegraph Company	17,640	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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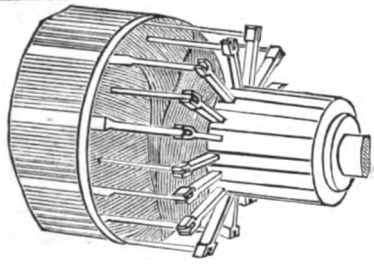
RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

2694. IMPROVEMENTS IN DYNAMO OR MAGNETO-ELECTRIC MACHINES, *W. R. Lake, London.—8th June*, 1882.—(*A communication from E. Weston, Newark, New Jersey, U.S.*) 6*d*.

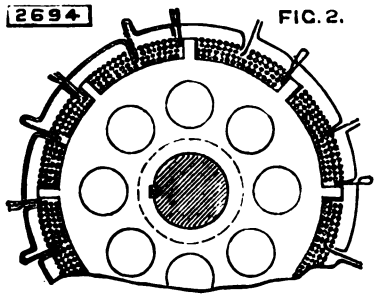
This relates to the winding of the armatures of the inventor's dynamo machines, and the object is to save time and labour, and, as far as the first part of the patent is concerned, to supply cur-

2694 FIG. 1



rents of high electromotive force. The method of winding is shown in Figs. 1 and 2. The claim is for "an armature wound with two systems of coils in diametrically separate divisions, the

2694 FIG. 2.

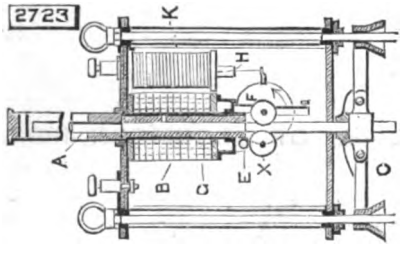


divisions of one system being alternately under and over those of the other system, and the said divisions being looped together and connected to the commutator." The other part of the patent relates to an armature wound so as to produce currents of great quantity.

2723. IMPROVEMENTS IN ELECTRIC LAMPS, *C. G. Gümpel, Leicester-square.—9th June*, 1882. 6*d*.

This relates to an arc lamp, the arc being regulated by two electro-magnets, one in the main the other in a shunt circuit. The invention will be better understood by the accompanying illustration. The upper carbon is fixed to a guided holder C, attached to a rod A passing through solenoid B, and counterbalanced by a weight connected to it by cords passing over pulleys. When the upper and lower carbons (the lower one being stationary) are in contact and the lamp

2723

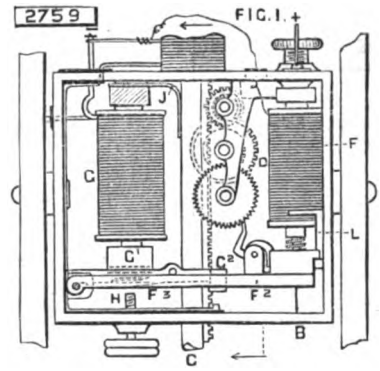


in circuit, coil B, of low resistance, becomes energised; core G is then attracted upward, and moving the bell crank E causes roller X to press against rod A, so that the latter is gripped between X and F, and by the continued ascent of the core the arc is struck. When the arc gets too long and its resistance great, the current passes through shunt coil K of high resistance. Its core H is then drawn upwards, and its pawl clamps the rim of wheel W, turning it in the direction of the arrow and causing the upper carbon to descend, so as to adjust the arc.

2759. IMPROVEMENTS IN ELECTRIC LAMPS, *H. H. Lake, London.—12th June*, 1882.—(*A communication from R. R. Moffatt, Brooklyn, New York.*) 6*d*.

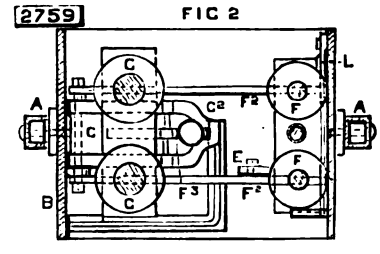
This relates to the regulation of arc lamps and to a means for cutting the lamps out of circuit. Referring to our illustrations, when electro-magnet G—Fig. 1—attracts its armature, G^1, the catch F^3 lifts the carbon-supporting rod C so as to establish the arc. G^1 is mounted on two levers, G^2, which are arranged between the levers F^2, and similarly pivotted to box B—see Fig. 2. These levers, G^2, are united at their free ends, and carbon-rod, C, passes between them. The

2759 FIG. 1.



catch F^3 consists of a bell-crank lever pivotted at the end of one arm to a rod which extends between the levers F^2 so that its angular position can act on C. The other arm is actuated by a spring so that the angular portion will be forced against C, when the arc is established and the electro-magnet G demagnetised, its armature descends with levers F^2, the outer arm of the catch stops against H, and on the further descent of the armature and levers the catch releases C and the upper carbon descends into contact with the lower. A derived circuit extends from box B to metal lever L, thence through a

2759 FIG 2



small contact piece to the electro-magnet, and thence through the insulating material in B to the wire. The armature of F extends between the two shoulders of L and shifts it so as to impinge on the before-mentioned contact piece or be removed therefrom. The armature, however, can move sufficiently far to cause pawl E to operate the ratchet wheel and feed the carbon downwards before it shifts L, so as to break the shunt circuit. When this is broken the armature descends and shifts L so as to re-establish the shunt, and if the arc be still too great the operation will be repeated.

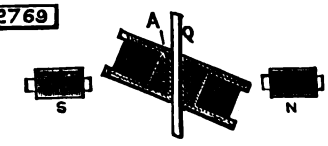
2752. IMPROVEMENTS IN THE CONSTRUCTION OF ELECTRIC LAMPS, &c., *J. Lane, Fulham.—12th June*, 1882. 6*d*.

This relates to incandescent lamps. Instead of mounting his filaments in the usual way the inventor fits them in a special plug, and inserts this into the neck of a glass globe and seals it there. A passage in this plug is utilised to produce a vacuum or to introduce non-combustible gases, and is then closed with sealing material.

2769. IMPROVEMENTS IN DYNAMO-ELECTRIC MACHINES, *J. Imray, Chancery-lane.—13th June*, 1882.—(*A communication from P. Jablochkoff, Paris.*) 6*d*.

This relates to the construction of dynamo-electric machines, the leading feature of which is the obliquity of the axis of rotation to the magnetic field as the axis of the earth is inclined to the plane of the ecliptic. The illustration represents a simple form of the machine. A bobbin, A, having cheeks of soft iron, and wound

2769

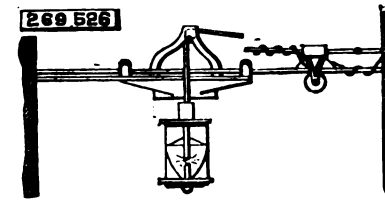


with a coil of insulated wire, is fixed obliquely upon an axis, O, and revolves between the poles of two electro-magnets, N and S. In each revolution the edges of the cheeks are presented alternately to N and S, as shown.

269,526. APPARATUS FOR SUSPENDING, RAISING, AND LOWERING ELECTRIC LAMPS, *Charles C. Jennings, Buffalo, N.Y.—Filed May 4th*, 1882.

Claim.—An apparatus for suspending, raising and lowering electric lamps, consisting substantially of supporting cables secured at their ends to the walls of a building or room, a carriage having arms provided with pulleys adapted to travel upon the supporting cables, and insulated brackets or hangers secured thereto, also provided with pulleys for the reception of the lamp-supporting cables, a cross arm having at each end

269,526

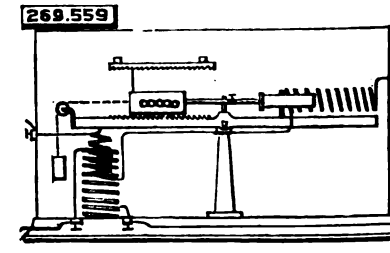


thereof a grooved pulley, pivotted to an insulated bracket or hanger to adapt the cross-beam to travel upon the carriage-supporting cables, supporting cables for the electric lamp, secured rigidly to the crossbeam and passing over the insulated pulleys upon the carriage to the lamp suspended below such carriage, and conducting wires connecting the positive and negative wires of the circuit with the supporting cables and the insulated pulleys of the crossbeam with the lamp-suspending cables, all combined and operating substantially as shown and described.

269,559. ELECTRIC-CURRENT METER, *Alex. Bernstein, Boston, Mass.—Filed October 4th*, 1882.

Claim.—(1) A current-meter composed of a scale beam, of a movable and counterbalanced registering device at one end of the beam, and of a fixed coil and a sliding iron core connected to the registering device at the other end of the beam, of a coil suspended below the end of the beam, carrying the register and placed in an auxiliary circuit with the coil at the other end of

269,559



the beam, and of a fixed coil of larger diameter and surrounding the suspended coil, and being placed into the main circuit, substantially as set forth. (2) The combination of a scale beam carrying a movable and counterbalanced registering device upon one arm, a coil and sliding core upon the other arm, a coil suspended from the arm carrying the register, a fixed coil surrounding the suspended coil, and a suitable stop mechanism, whereby the register is stopped when the equilibrium of the parts takes place, substantially as and for the purpose set forth.

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SLIP

PARA.—The cable between Para and Maranham is again interrupted.

TURKEY.—The cable between Constantinople and Odessa is interrupted.

TELEGRAPHY IN PARIS.—The pneumatic system of despatching telegrams in Paris is to be largely extended after the 1st of April next.

CANADIAN TELEGRAPHS.—The Government telegraph line between Winnipeg and Regina is now in good working order. —*Colonies and India.*

THE HAMMOND COMPANY.—The Hon. Sidney Carr Glynn, M.P., has joined the board of the Hammond Electric Light and Power Supply Company.

THE CARCEL.—It may be of use to some of our readers to be reminded that the "carcel," or photometric standard in use in Paris, is equivalent to 9·6 English and 8·7 German candles.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of January, 1883, amounted to £32,822, and to £33,129 for the corresponding period of 1882.

AMERICAN LAND LINES.—A telegram from Philadelphia, dated February 5, stated that a heavy storm, which had raged in the west during the previous week, had caused great destruction of telegraph lines.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended 31st January are £2,551, as compared with £2,851 in the corresponding period of 1882.

THE LIGHTING OF HOLBORN-VIADUCT.—The Edison Company have received permission from the Commissioners of Sewers to continue the lighting of Holborn-viaduct by their system for one year from the 24th ult.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for January, 1883, amounted to £18,240, against £17,110 for the corresponding month of 1882, and £17,352 for the same month of 1881.

TUNSTALL.—This Staffordshire town is quarrelling with its purveyors of gas—the British Gaslight Company. The present charge is 3s. 6d. per 1,000 cubic feet, whilst the townsfolk think it should not be more than 2s. 6d.

FAILURE.—A recent *Gazette* announces that the first meeting of the creditors of Edward Penty, electro-plater, of 79, New Briggate, Leeds, will be held at the office of Mr. W. Wells, 16, Cookridge-street, Leeds, on the 13th inst., at 2 p.m.

INDIA RUBBER, GUTTA PERCHA, &c., COMPANY.—The nineteenth ordinary general meeting of this company will be held at the City Terminus Hotel, Cannon-street, E.C., on Tuesday next, at 12 o'clock noon. The report of the directors will be found in another column.

THE TELEGRAPH CONTROVERSY IN AMERICA.—A telegram from New York, dated February 7, says:—"The contest between the Western Union and the Mutual Union Telegraph Companies has been settled, the Western Union having agreed to lease the Mutual Union's lines."

VIENNA ELEVATED RAILWAY.—A concession has been granted by the Austrian Emperor for the construction of this long-talked-of railway. It is said that it will be constructed by an association formed by the Messrs. Fogerty, of Middlesbrough. Electromotors are to be used on it.

MORSE SLIP.—The English Post Office has just issued an order that in future the Morse and Wheatstone slips need not be preserved but, after being transcribed, are to be treated as waste paper. By this order the last vestige of a "record" in the British postal telegraph system is done away with.

POST OFFICE TELEGRAPHS.—An open competition for admission to the Post Office (Female) School of Telegraphy (age 14-18) will be held in London on the 26th February. Particulars and the necessary form of application can be had of the Secretary, Civil Service Commission, London, S.W.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY. —The directors of this company propose (subject to the audit of the accounts) paying a dividend of 15 per cent. (£1 16s. per share), in addition to the *ad interim* dividend of 5 per cent. already paid, making 20 per cent. for the year 1882.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of January was 2,953, estimated to produce £2,800, against 3,029 messages, producing £3,021, in the corresponding month of last year. The traffic receipts for the month of October, estimated at £2,000, realised £1,986.

TELEPHONIC COMMUNICATION WITH LIGHTHOUSES.—Mr. Chamberlain was asked at Swansea last Friday whether the Government would assist the establishment of a telephone wire between Lundy Island and the mainland. It is understood that Lloyd's have now determined to erect one within six months, provided they can obtain a subsidy of £600 a year from merchants and others on the Channel.

THE LIGHTING OF BATH.—The Town Council of Bath have awoke to the fact that the present lighting of the streets is "discreditable." To improve it they are going to substitute 6ft. for 4ft. burners, and introduce large gas lamps at certain points, and for this they are going to pay £57 more per annum than at present. The town council are by no means unfavourable to electric lighting.

A CHINESE TELEGRAM.—Among the Sovereigns who sent their congratulations to the Crown Prince and Crown Princess of Germany upon the occasion of their Silver Wedding was the Emperor of China. His telegram, which was in Chinese, was despatched from the Imperial Palace, Pekin, to Berlin, on the 25th ult. This is said to be the first telegram sent by the Chinese Sovereign to a European Prince.

THE SANITAS COMPANY.—The report of the directors of this company for 1882 states that the sales amounted to £11,443, as against £8,580 for 1881. They recommend a dividend of 5 per cent. for the year. The report further states that Sanitas disinfectants have been supplied to upwards of 600 corporations, railway, and other companies, &c., and that the company have been appointed contractors to H.M. Admiralty.

ELECTRIC LIGHTING IN BUDAPEST.—Electric lighting is progressing in this gay Hungarian town. We hear that Herren Ganz and Co. are to light up the National Theatre by means of 1,000 Swan lamps; that they are already fitting up 200 similar lamps in a corn mill there; and that the Café Steenassger, on the Corso, is lighted by means of lamps, the invention of Herr Zipernowsky, whose patronymic does not sound Hungarian.

NEW TELEGRAPH LINE IN CHINA.—A telegram to the *Daily News* of last Saturday stated that the Chinese representative at St. Petersburg had notified the Russian Government of the readiness of the Chinese Government to undertake the expense of establishing telegraphic communication

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between Pekin and Kiachta. A subsequent telegram from *The Times'* St. Petersburg correspondent, however, stated that this was untrue.

THE COST OF ELECTRIC LIGHTING.—Champagne has not yet been sold for the price of beer, says the *Engineer*, but there can be no doubt that money is made by champagne growers, and there is good reason to believe that the demand for it is practically unlimited. We may regard electric lighting, as representing champagne, while gas stands for beer, and feel confident that the public will willingly use the former, even though the price should be higher than gas.

A NEW MEDICAL BATTERY.—A handy little battery, which the proprietors call the medical constant current electric generator, has just been introduced from America, and is now on view at 38, Lombard-street. It is said to be the invention of Mr. Hopkins, the editor of the *Scientific American*, and consists of a zinc and copper plate, separated by bibulous paper, the whole enclosed in a small ebonite box not much bigger than a card case, and can, therefore, be carried in the pocket or placed under the pillow. Convenient electrodes are attached for application to the body.

ELECTRIC RAILWAYS.—Owing to the sudden cessation of Court festivities at Berlin, consequent on the death of the Emperor William's brother, His Majesty's physicians have been somewhat at a loss how to provide suitable recreation for him. A happy thought seems to have suddenly occurred to them, however, viz., that of interesting scientific lectures. No sooner said than done, and accordingly the first of a series of such lectures was given before the Emperor and other members of the royal family by Dr. Werner Siemens a few days ago. His subject was electric railways in general, and the elevated electric railway with which he hopes to provide Berlin, in particular. His audience are said to have listened very attentively.

EXTRACTING GOLD.—Mr. R. Barker has patented a process for extracting gold from its ore, by causing it to be washed by a stream of water over an inclined table, in which are placed at intervals "riffles," or baths of mercury. The mercury is connected with the negative wire of a dynamo machine (Elmore's has been used up to the present), and the positive wire is lead to the water. By this means it is found that the mercury readily seizes on and holds the particles of gold, and never "sickens," as has hitherto been the case. The patent has been taken up by the Electro-Amalgamator Company, of Tower-chambers, Moorgate-street, E.C., who have erected experimental works near London Bridge, where the process was shown in operation recently.

INTERNATIONAL ELECTRICAL EXHIBITION, VIENNA.—We stated in a recent note that an International Electrical Exhibition will be held in Vienna, under the patronage of the Austro-Hungarian Government, in the months of August, September, and October next. At the request of the Austrian Minister of Commerce, and of the Managing Committee of the Exhibition, the Council of the Society of Telegraph Engineers have appointed a committee to receive applications for space from British exhibitors, and for promoting generally the formation of a British section. Application should be made as early as possible, and should be addressed to the Secretary of the Society of Telegraph Engineers and of Electricians, 4, The Sanctuary, Westminster, S.W.

ORNAMENTAL ELECTRIC LIGHTING.—An ornamental design in the shape of a monogram composed of Swan incandescent lamps has just been completed for Mr. Vanderweyde's photographic studio in Regent-street, W. The monogram is in the shape of a V superimposed on a W, the V being marked out by lamps having ground glass globes, and the W by lamps having plain globes. The current is derived from an A Gramme dynamo, driven by an 8 horse-power Otto gas engine, which Mr. Vanderweyde has for some time had in use. Forty lamps altogether are employed. The design was executed, and the lamps supplied, by Messrs. Laing, White, and Wharton, of Holborn-viaduct, E.C. The effect is said to be very good, and we do not doubt that other people will follow Mr. Vanderweyde's example.

A FAILURE OF GAS.—On the evening of Friday, the 2nd inst., a large part of the town of Halifax was suddenly deprived of light owing to a failure in the gas supply. The breakdown is attributed to water having got into one of the mains. Many mills and factories had to stop working, the railway stations were left in darkness, and generally things were uncomfortable in Halifax on Friday evening. Seeing what a vast amount is made by the journals representing the gas interest out of the occasional failures or breakdowns which occur in electric lighting, we think we may as well draw attention to the fact that gas is by no means infallible, even in a large town, where everything should be in apple-pie order. If we were to refer to every little breakdown in gas lighting in small towns and out-of-the-way places, we should have little room for other matters.

ELECTRIC LIGHTING IN HOLLAND. — Our Amsterdam correspondent sends us the following information:—The Nederlandsche Electriciteit-Maatschappij, who are sole agents for the Edison system in the Netherlands, have fitted up 30 lamps in the factory of Mr. C. W. Schonebaum, at Groningen. A chandelier, fitted with 12 A lamps, does duty in the office, and is supplied with a regulator, so that any intensity of light can be used. A larger installation has been made in a refinery known as the Westersuikerrafenadenij, where two Edison K dynamos generate current for 380 sixteen-candle lamps. The work in both cases was successfully carried out under the superintendence of Mr. H. C. Van Mens, engineer to the Nederlandsche Company. We may add that it is hoped that the Edison system will be employed to light the new theatre which is to be opened in Amsterdam this year.

PRESENTATION TO A TELEGRAPH SUPERINTENDENT.—From the colums of the *Daily Gleaner*, of Kingston, Jamaica, we learn that the energy and ability displayed by Mr. H. C. Wilson, superintendent of inland telegraphs in Jamaica, in establishing telegraphic communication throughout that island, have been recognised by the Jamaica staff. In December last Mr. Wilson was presented with a valuable gold watch on behalf of the whole staff in recognition of his services. On one side of the case are Mr. Wilson's initials, and on the other a gauntleted hand grasping a sheaf of lightning flashes, and the letters "K.N.," which is the Kingston "call." Inside the case is the inscription, "Presented to H. C. Wilson, Superintendent Government Telegraphs, Jamaica, by the entire Staff, 1882." We also learn from the *Gleaner* that Mr. Wilson rendered valuable help during the late disastrous fire at Kingston.

ELECTRIC LIGHTING FOR THE HOUSE OF COMMONS.—The Edison system of incandescent lighting is to be introduced into the House of Commons, so far as the corridors and passages are concerned. The Edison lamp will not, however, be used for lighting the House itself, as the gas has been found to answer all the requirements of the members and officers of the House. In many of the corridors and passages, especially those leading to the conference room, the tea room, and the library, the gas lights have been found rather ineffective

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so much so that where flights of stone steps had to be descended there was a certain danger of stumbling to persons with poor eyesight. In addition, the long series of stone steps by which ascent is made to the Reporters' Gallery has been, under the gas system, miserably lighted. All these defects will, it is hoped, be wholly remedied by the introduction of the Edison incandescent lamp.

Electric Lighting at Cardiff.—Cardiff Castle, the residence of the Marquess of Bute, has been lighted by means of Swan incandescent lamps. On the occasion of a dinner given by the marquess last week in honour of the inauguration of the work of constructing a new dock at Cardiff, the banqueting hall was entirely lighted by their means, and the effect is spoken of as magnificent. The library and grand staircase are also lighted by Swan lamps, and we venture to think that the increased life thereby guaranteed to the noble marquess's books will render the lamps a permanent feature in his library. The work was carried out for the Swan United Electric Light Company by Mr. W. H. Massey, whose name will be familiar to our readers as having done some excellent work in Cardiff and elsewhere before. The new dock works will be carried on by night as well as day, the contractors, Messrs. Nelson and Co., of Carlisle, having determined to use arc lamps to enable this to be done. We may add that the installation at Cardiff Castle comprises 300 Swan lamps.

Telegraphic Extension in Shetland.—Mr. Laing, M.P. for Orkney and Shetland, has written to Mr. Garriock, of Lerwick, with reference to the proposed telegraph extension to fishing stations on the west coast of Shetland. Together with Mr. Laing, Lord Rosebery, Sir Donald Currie, M.P.; Mr. J. C. Dundas, M.P.; and Mr. John Pender, M.P., will co-operate in urging the Treasury to appropriate from the Herring Brand Fund the guarantee required for the Post Office. Mr. Laing states that the Scotch Fishery Board has been informed by the Treasury that it will adopt any estimate by the Board for thus applying the surplus of the Herring Brand Fund. Mr. Laing further states that the Scotch Fishery Board have now recommended this course, and that the matter may thus be considered settled. Mr. Pender writes approving of the movement, and thinks the Government ought to connect by telegraph every outlying place in the country, not only for fishery purposes, but as a matter of security. He is further of opinion that poorer places should be helped out of the superabundance of richer ones, and that the Government has no right to make the telegraph system simply one of revenue. They ought to look more to public interests and the requirements of trade. When Parliament meets he thinks a deputation from districts interested should wait upon the Postmaster-General to urge this policy.

The Gulcher Electric Light Company.—In our recent review of the electric lighting work of the past year we were unable to include that done by the Gülcher Company, owing to the information not being to hand. We may mention now, however, that this company supplied lamps and machines for erection in the following works, &c., during 1882:—The collieries of the Earl of Durham, the Patent Shaft and Axletree Company's works, Wednesbury; the Oude and Rohilkund Railway Company, for lighting their new bridge across the Ganges at Benares; Messrs. Morewood and Company's Soho Iron Works, Birmingham; Messrs. Joseph Sykes and Company's Cloth Mills, Huddersfield; Messrs. Evans and Owen's premises, Bath; Messrs. Ransomes and Rapier's works, Ipswich; Messrs. Miles Brothers and Company's establishment in New Zealand; to Mr. J. Oppenheimer, of Manchester, for shipment to Australia; Messrs. Schoeller and Sons' establishment at Zurich; and the Telephone-Industrie-Gesellschaft, Zarich. We are further informed that in almost all of these installations both arc and incandescent lamps are being run from the same dynamo machine, an advantage which is peculiar to the Gülcher system. Besides carrying out the above installations the light was exhibited with success at the Horticultural and Botanical Fêtes, at the North East Coast Exhibition, Tynemouth, and at the London Hospital.

Telegraph Clerks' Grievances.—A largely-attended meeting of the Liverpool postal telegraph clerks was held in Liverpool on Saturday evening last, at which delegates from Manchester, Preston, and other towns were present. The following was the first resolution passed:—"That this meeting is deeply dissatisfied with the scheme of revision applied in 1881 to Her Majesty's Telegraph Department, and cannot regard as final any scheme which fails to satisfy claims put forward in the petition of the postal telegraph clerks of the United Kingdom to the Postmaster-General in 1881." It was stated that Mr. Fawcett's scheme retained a system of classification which would prevent all but a few of the junior clerks from ever obtaining a salary higher than 38s. per week, although many of them were now old servants of the department, and that the maximum salary given to first-class clerks amounted to only £130 per annum. The petition referred to proposed to abolish classification and to introduce a scale of salary rising from 16s. per week by 2s. per week each year until £200 per annum was reached. It was explained that this would place the Telegraph Department in no better position than that of other departments of the service, where the work done was of less importance and less onerous, and did not require more intelligence or skill; and it was urged that the moderation of the proposal was shown by the fact that so long a service as that of 31 years would be necessary to reach the maximum salary. The second resolution was as follows:—"That this meeting calls upon the Central Committee of the Postal Telegraph Clerks' Association to use every legitimate means to obtain the concession of the claims put forward by the postal telegraph clerks of the United Kingdom in their petition of 1881." The mover of the resolution said that these claims had been deliberately framed, and would not be abandoned. For some time little had been heard of the movement, but the reason of that was that the leaders wisely determined to refrain from hampering the heads of their department at a time of great political anxiety; but while deferring to the prudence of such a course in the past he viewed with satisfaction the signs of increased activity, for the time had now arrived for a renewal of their demands, and the clerks throughout the country were prepared to act with greater vigour. In every town of importance meetings would shortly be held, and their claims, which all along had had the support of those best qualified to pronounce upon their justice—viz., the Press and the commercial public—would still meet with that support, and by its aid their cause could not fail eventually to succeed. The resolutions were passed unanimously.

Transmission of Power by Electricity.—The correspondents of three daily papers have each sent to their respective journals glowing accounts of some experiments made by M. Marcel Deprez on Tuesday last, to illustrate the transmission of power by means of the electric current. The *Daily News*' representative said:—"Interesting experiments were made to-day (Tuesday) in the workshops of the Northern of France Railway on the system of M. Marcel

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Deprez, the greatest authority on electricity in Paris, for transporting force over great distances. A dynamo-electric machine transported a force equal to about 3 horse-power a distance of 20 kilometres by means of a single ordinary iron wire, and afterwards 10 horse-power over a distance of 35 kilometres. Hitherto it has not been thought possible to transport a force beyond two kilometres with a minimum loss of 50 per cent., although thick copper wires were used as conductors. The French Syndicate of Electricity, presided over by an American, Dr. Cornelius Herz, and of which MM. Hebrard, Bapts, Reinach, and Dalloz are members, are about to construct a generating Deprez machine of 1,000 horse-power, which is to distribute for practical application 500 horse-power over a distance of 100 miles." The *Daily Telegraph* gives a similar account of the experiments, with this difference. Its representative says:—"Upwards of 3 horse-power was first transmitted a distance of 20 kilometres, and then 35 kilometres, by means of an ordinary wire four millimetres in diameter." It will be observed that the *Daily News* said 10 horse-power was sent over a distance of 35 kilometres. The *Standard* gives the same figures as the *Daily News*. It varies its description, however, by saying that at previous trials "as much as 5 horse-power had been sent through, but yesterday (Tuesday) only 3 horse-power was transmitted." It mentions also that "some incredulity appeared to prevail at first, but in the end it was clearly established that 3 horse-power was transmitted." We would call attention to the fact that none of the accounts mention the actual power that was put into the transmitting machine, with the exception that the loss incurred in transmission is given as about 50 per cent. From private information we may say that we have the best of reasons to believe that of the horse-power put into the transmitting machine, not one-third was given out at the receiving machine. Several Englishmen were present at the experiments, and we do not think they were at all satisfied with the success attained. We admire M. Deprez for his experimental pertinacity, but we do not think that he can be said to have reached anything like the point necessary for the practical carrying out of his system with economy. It would be as well if these experiments were not quite so much noised abroad by that portion of the Press which knows next to nothing about the question, as it is easy to entirely mislead the public without intentionally misstating facts.

Electric Lighting and Plant Growth.—In the Chemical Society's *Journal* for January is an abstract of a paper by M. P. P. Déhérain in the *Annales Agronomiques*, Vol. 7, pp. 551—75. The author's experiments were made at the Palais d'Industrie during the electric exhibition of August, 1881. A green house was constructed and divided into two compartments, one of which was glazed with blackened perfectly opaque glass, whilst the other was exposed to the ordinary diffused daylight of the exhibition building. The darkened chamber was illuminated continuously, night and day, by a 2,000 candle arc light from a Gramme machine, driven by an Otto gas engine. The transparent chamber was illuminated at night only by the electric light. Five series of observations were made, viz.:—1. Plants exposed night and day to the electric light alone. 2. Plants exposed during the day to the diffuse daylight of the Palais, and during the night to the electric light. 3. Plants living during the day in the open air, and receiving the electric illumination at night. 4. Plants passing the day in the diffuse daylight of the Palais, and the night in darkness. 5. Plants living normally in a garden. The plants submitted to experiment were barley, flax, beans, and a number of garden and greenhouse plants. At the end of seven days the naked electric light was seen to have an injurious effect both on those plants which were constantly subjected to it, and in a less degree on those which were exposed to it during the night only. The leaves blackened, withered, and dropped off; the injury was confined to the epidermal layers, and was due to the direct impact of the luminous radiations (and not to the formation of nitrogen oxides); for where one leaf was partly shaded by another, a sharp line was photographically impressed. Experiments on *elodea canadensis*, submerged in flasks of water, showed that whilst the diffuse daylight of the building was unable to cause decomposition of carbonic anhydride and evolution of oxygen, the direct rays of the electric light were able to do so, about as much oxygen being obtained during an exposure of four or five days and nights to the electric light as could be obtained in an hour or so in bright sunlight. At the end of 15 days the arc lights were enclosed in globes of transparent glass, Siemens's just published experiments having shown that the injurious action of the direct radiations was thereby modified. A number of fresh and uninjured plants were placed in the greenhouse, and, in addition, sowings of barley, oats, peas, maize, beans, which had just appeared above the ground. All the seedlings exposed exclusively to the electric light perished sooner or later, and the leaves of some of them were blackened as with the naked light. The mature plants, on the other hand, continued to vegetate, but in no case, save a plant of barley, were flowers and seeds produced, the vegetation being purely foliaceous. The barley grains were normal, and germinated on being sown. The electric light employed was clearly insufficient by itself to determine the assimilation of any considerable quantity of material. Direct experiments also proved that it is not more powerful in exciting transpiration of water, a leaf exposed to it giving off in an hour only about one-fiftieth of the quantity of water evaporated under similar circumstances in sunlight. As the evaporation of water by the leaves is one of the chief agencies in causing the migration of material necessary for the maturation of seed, the failure of the plants to produce flowers and seeds receives its explanation. It is known that yellow and red rays are most powerful in causing transpiration, whilst the electric light is particularly rich in blue and violet rays. The author considers the electric light employed as too feeble to allow of any conclusion as to the necessity of a nocturnal rest to plants. It was, however, evident that the electric illumination during the night was advantageous to those plants which passed the day in the rather feeble diffused daylight of the Palais. In a third series of experiments the intensity of the electric light was practically augmented by placing the plants nearer the lamp. The experiment was again fatal to young seedlings receiving the electric light exclusively, but many of the hardier and more mature plants survived, although the leaves of some were blackened by their two great proximity to the light; and again the nocturnal electric illumination was decidedly favourable to the plants which passed the day in the light of the Palais. The author sums up his conclusions thus:—1. The electric arc light emits radiations which are injurious to vegetation. 2. Most of these radiations are arrested by colourless glass. 3. The electric light emits radiations powerful enough to maintain mature plants in vegetation for two months and a half. 4. The beneficial radiations are not sufficiently powerful to cause the growth of germinating seeds or to allow of the maturation of fruit in older plants.

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THEORY OF MICROPHONE AND RESISTANCE OF CARBON CONTACTS.

BY OLIVER HEAVISIDE.

That a joint between two wires required to be firmly made in order to make good continuity for the current was probably learnt by the very earliest experimenters in galvanic electricity. It certainly became matter of common knowledge when telegraphs were practically introduced, and it may have been often noticed that the current passing a contact was decreased when the pressure relaxed before becoming actually interrupted. Now that we know how easily this fact lends itself to the electrical transmission of speech, it seems (after the event) surprising that it was not done generations ago. The nature of acoustical vibrations was known, and with the knowledge of the variation of current with pressure little more was required. We can now make a Morse key transmit speech; very badly, it is true. But the best microphone transmitters are bad enough, so what can one expect from a Morse key?

However, it seems to be established that Reis utilised the phenomenon in his transmitter, long erroneously supposed to work only by makes and breaks. Indeed, presuming that he was at first unacquainted with it, and to be adjusting his transmitter very finely, it would have been difficult for him to have *not* noticed that the current passed continuously with very light contact; and the wonderful change produced thereby, a harsh, disagreeable tone being replaced by a soft and smooth one, would be unmistakable. And, in fact, he did transmit speech in this way with unbroken current. If Reis had but employed carbon contacts instead of metallic, there can be little doubt that the practical introduction of telephony would have been much accelerated.

But, not to enter upon matters historical or controversial, or the labours of subsequent experimenters and inventors, why does the current passing a light contact vary with the pressure? In a sense the theory of the microphone is not affected by the answer, for, only granting the fact, this theory follows immediately:—That we make a light contact in a circuit, vary the pressure between its members by setting it in vibration, vary the current in a somewhat similar manner, vary the attraction on the telephone armature, and set it vibrating. With so many transformations from the speaker to the telephone disc, it would not be fair to expect an exact reproduction of his voice. And we do not get it. It is recognisable, and even intelligible, if one has good ears. It is said that some of the Middle Age artists used to write "This is a horse," &c., by the side of their representations, to prevent any misconception. Something of the same kind is really wanted with some microphone transmitters in extensive use. A stranger requires to be told what the funny noise is meant for, and then he may understand it. Some never do.

In a certain transmitter, which is, relatively speaking, a good one, one contact piece is fixed to the centre of a thin board, the sound board in fact, and the other is mounted upon a spring and presses gently against the first. This is only the Morse key arranged for continuous light contact, arranged to be worked by the air vibrations instead of by hand. The sound board is spoken to, it moves to and fro and varies the pressure, and there is, or should be, no jolting, or scraping, or interruption of the current.

Professor Blyth's arc microphone seems to be a thing *sui generis*. There is no visible contact; a strong current is employed to maintain an arc, and it can be made to transmit speech. Granting that, according to Professor Blyth, the action is really direct action of the air vibrations on the arc (though how the electrodes are to be stopped vibrating by making the fixtures heavy is not very evident), it yet seems an extraordinary step to take to conclude that the same thing happens in contact microphones, that the tremor breaks contact, sets up arcs, which are then acted upon directly by the air vibrations. The fact that a strong current is required in the arc arrangement, and a circuit of low resistance, alone seems sufficient to invalidate the conclusion. But when we consider that in a contact microphone the slightest discontinuity, the least amount of sparking, at once spoils the microphonic action, the whole ground of the explanation seems undermined.

Granting, now, that there is no arc in the ordinary sense, as there could not be with such relatively considerable pressures as can be employed between the contact pieces without so much enfeebling the action that no sound is given out by the telephone, there is yet much to be learnt concerning the nature of the apparent assistance which is presented by a contact. I made some time ago numerous experiments on this subject, which led me to the conclusion that it was principally the air that was concerned, and I am confirmed in this belief by Mr. Berliner's interesting communication (*Electrician*, p. 135 *ante*), in which he states a good case against the arc theory, and that a Blake transmitter in vacuo had only 2-10ths of an ohm resistance, which was that of the air left.

There is, or seems to be, a cushion of badly-conducting air between two pieces of carbon in contact, which air is partially squeezed out by increasing the pressure, and the resistance is simultaneously reduced, more points or a larger surface of carbon being brought into real contact, if there be such a thing. At any rate, this is in harmony with the difficulty of ensuring a really good connection between wires, considerable pressure being required. In soldering, also, the solder displaces the air, and, besides enlarging the area of contact, of course stops the oxidation that the displaced air would cause.

But there is uncertainty here. We do not know whether the conduction takes place between those parts of the carbon pieces which we may assume to be in real contact—conduction of the metallic nature; or whether there is conduction through the air elsewhere; or whether there is any real contact at all (except under considerable pressure) so that the conduction is invariably through a layer of air, apparently continuously and without disruption, though if the discharges were only sufficiently rapid, we should know nothing of them.

If we have two carbon pieces with flat surfaces, place them in contact equally parallel, and have them mounted so as to be capable of to-and-fro motion; and if we assume that with increased pressure more points are brought into contact, which is reasonable enough, and, further, that the conduction is of the metallic nature, we can deduce these results. The contact resistance should vary inversely as the area with the same pressure, and be independent of the current strength. Two similar contacts, separately adjusted to exactly the same resistance, should present double the resistance when put in sequence, and half the resistance when abreast; and similarly for other combinations. We should be able to arrange contacts like battery cells, in tandem, and abreast, so that when all were similarly acted upon with the same vibrations we should obtain the greatest variation of current in the circuit. The best arrangement for a definite variation of pressure would be that in which the resistance of the external circuit, supposed constant, and containing a constant E.M.F., equalled the geometrical mean of the highest and lowest resistance of the combination of contacts under the given change of pressure, which we may consider as approximately equal to the resistance when in quiescence.

But all this is wrong. The resistance is not independent of the current for the same pressure, but varies considerably when the pressure is light, so that all conclusions based upon Ohm's law, $E = RC$, with R independent of C and E, are erroneous. The contact conduction can therefore be only partly of the metallic nature, mostly so when the pressure is not very light, for there is then the least departure from $R = \text{constant}$; and the air therefore probably plays an important part in conducting the current, besides serving to prevent metallic contact, and a part of the apparent resistance is of the nature of a back E.M.F.

To make exact observations, contacts, though light, should not be loose. They must be definite, capable of easy regulation, and of exact reproduction as regards a given state. For this, there seems nothing better than to fix one piece rigidly to the sound board, and the other piece on the end of a light flat spring, whose further end is securely fixed to some place where there is compartively little amplitude of vibration. If the spring be horizontal, the most feeble pressure

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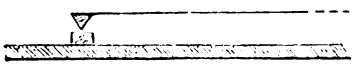
may be obtained by first adjusting to nearly give contact, and then placing a small weight on the spring; and, by altering its position, the pressure may be varied by very small amounts. The connections should be so arranged that



there is no straining of the spring by wires, or of the board either, as great differences in the current passing may arise from shifting wires.

The elementary contact is that between a point and a *plane*, not between two points. The point, to localise the discharge; the plane, because it does not require any adjustment to meet the point, which should only have motion perpendicularly to the plane. So one piece of dense carbon may be ground to a cube, or, at any rate, with two flat parallel surfaces; the other to a point, with a flat side opposed. All dust should be removed, as it introduces irregularities.

Join up with a battery, a telephone, and a galvanometer (say a tangent, to measure current-strength). The galvanometer is indispensable, for the telephone gives us little information as to current strength; and the telephone should be used constantly, as it tells us a great deal about the state of the contact that the galvanometer cannot. No bridge, and no induction coil. The bridge is of no use for such variable resistances as are presented by very light contacts, and especially so when the resistance varies with the current strength. To measure roughly the resistance r of a contact, observe the current before it is introduced into the circuit and after, say, C and c; then $r = \frac{E}{C} - \frac{E}{c} = \frac{E}{G}(\cot\theta_2 - \cot\theta_1)$, where G is the galvanometer constant, E the E.M.F. of the battery, θ_1 and θ_2 the deflections. Thus, r is proportional to the difference of the cotangents. To obtain suitable falls of deflection, vary the resistance of the circuit or vary E.

If we have, say, a dozen contacts, as above, and observe their resistance and microphonic action under different pressures, no two of them will behave exactly alike. There is, however, in the majority of cases, a general resemblance, and the following I found to be typical. If the point be heavily weighted, there is no appreciable resistance; with very light pressure there is a considerable fall in the current. If the contact be then let alone, the current will remain nearly steady for long periods, with only slow variations of not great amount. Using one cell Leclanché in a circuit of 72 ohms resistance without the contact, with deflection 54deg., when the deflection fell to 50deg. by reducing the pressure, indicating a contact resistance of 11·2 ohms, the sound of a watch placed upon the sound-board as a constant source of sound was just audible in the telephone. The sound increased, though not very rapidly, until 35deg. was reached, indicating a contact resistance of 70 ohms. From 35deg. down to 20deg., when the resistance was 202 ohms, the sound increased much faster, and was now about three times as loud as that of the watch itself when placed close to the ear instead of the telephone. Below 20deg. the microphonic action became imperfect, due to slight breaks mixed up with the proper continuous action; and at 15deg. (resistance 300 ohms) the contact broke suddenly, and could not be permanently maintained at that pressure. If the deflection were above 20deg. it could be maintained nearly constant for a long time, with perfect microphonic action without sparking. (Watch with face upwards, for when placed the other way, glass upon board, there was a violent kick at every second tick, which broke contact.)

The point at which the watch became audible was naturally very variable, as it depended so much on quietude. Again, the point at which the break occurred was variable with different contacts, as any slight noise was sufficient to cause the break. But below a certain point, the current once broken would not remake itself. It required the assistance of a touch, or another noise. This was independent of any permanent change of pressure.

Some contacts, however, though seemingly just the same as the rest, would not behave regularly. The sound was as usual in the earlier stages, though not so good as it should have been; but when the later stages were reached, say at 30deg., there was a stoppage of the regular sequence. Poor action. Left to itself, the contact changed so that the current through it, instead of remaining steady, decreased rapidly, the deflection sometimes going down to zero (or less than ½deg. at any rate); and whereas the normal contacts were at their best, microphonically, nearly up to their breaking point, these abnormal contacts got worse and worse, the sound becoming feebler and feebler, though even with no visible current passing the watch was still faintly audible. This "bad" behaviour also varied capriciously, the current undergoing changes somewhat like earth-currents (except as regards reversal of direction), *i.e.*, gradual, but great. I was never able to settle decisively the cause of this; sometimes carbon dust produced a similar effect; sometimes repointing the point or replaning the plane removed the evil, but frequently it did not. So, although bad contact in one sense is essential to microphonic action, yet there must be good contact in another sense. All such bad contacts were rejected in making comparisons later, only the normal ones being used. Sometimes a contact which had been good for many days got wrong, in some unknown manner, and behaved in the bad fashion, and stuck to it too.

Of course a contact when adjusted so finely as described would not do for speaking purposes, as it would break at every syllable; but it answers for distant and faint sounds, whether speaking or not, a German band down the street, for example, or distant church bells. There must be no sparking whatever if the continuous microphonic action is to be preserved. Sparking is generally easily distinguishable by the peculiar sound it causes, and when the telephone indicates its existence it may be detected by ocular inspection, unless it be very minute. The microphonic action is loudest and best (for feeble sounds) when the current is least (excepting in the case of the "bad" contacts). The deflection is the same whether the sound-board be vibrating or not, except that there is a slight fall for loud sounds, even when they do not break the contact, thus showing that the average current is somewhat reduced. At the same time it is noticeable that the watch-sound gets louder when there is another sound going on, without any particular fall in the current. What the extent of variation of current is, the galvanometer will not say. It may be roughly guessed from the intensity of sound produced by breaking the circuit, and this only tells us that the variations are very small when speaking to a transmitter with coarse adjustment, and very great, perhaps as much as 30 to 50 per cent., when the adjustment is very fine, and the sound-board motion is nearly sufficient to break the contact. The disc of the telephone (a flexible disc) could also be felt to be strongly vibrating when a finely adjusted transmitter was spoken to, care being taken not to break contact.

Now regarding other forms of contact. If we round the point slightly like a worn lead-pencil point, we get substantially the same results, both as regards resistance and the corresponding intensity of sound; but it is not so perfect in the finer stages, and it is the same with any kind of contact substituted for the point, if the current passes always at one place. On the whole, though, they are more irregular than points, and the more so the flatter they are.

Flat contacts are peculiar. If the two surfaces be not exactly parallel, they will only touch at a corner, or along a portion of an edge of one of them, and the behaviour is not much different from that of a point and plane; but if care be taken to grind them quite flat, and to mount them so that, on slightly separating them, sparking can be seen to go on quite irregularly at various places, so that we may be sure that the surfaces are practically parallel, then, when brought into contact by slightly weighting the upper one, we know that there is contact at many places, and we find that it behaves perfectly abominably. The regularity of action is quite gone as regards the state of fine adjustment, and it is vastly inferior to a point microphonically. The resistance, instead of being less, is, with light pressure, usually much higher and the current varies, as with a "bad" point. Therefore flat contacts were rejected.

With respect to the resistance of a contact, it varies accor-

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ding to the current passing. But there are two principal ways of considering the resistance. We may calculate it as resistance by Ohm's formula, and we then find that it decreases greatly as the current rises, with the same pressure; the current being made to vary by inserting or removing resistance from the circuit, or by varying the number of cells in the battery. Or we may reckon it as a back E.M.F. without resistance, say e, so that if E is the battery E.M.F., $(E - e)$ is the actual E.M.F. in the circuit, on the assumption that the real resistance is that of the rest of the circuit. We now find that e rises with the current, though not nearly so fast as the resistance falls on the former assumption. There is probably both a back E.M.F. and resistance at a light contact, but it is not easy to separate them, owing to the variations going on. As far as mere calculations go, it is simpler to employ e, especially with combinations of contacts.

The resistance r on the assumption of no back E.M.F., and the back E.M.F. e on the assumption of no resistance, are thus connected. Let E and R be the E.M.F. of battery and resistance of circuit without contact, and let the current fall from C to c on inserting the contact. Then,

$$c = \frac{E - e}{R} = \frac{E}{R + r} = \frac{e}{r}.$$

In the example before mentioned of a typical point and plane contact we have

$c =$	20·6 ...	17·8 ...	10·5 ...	5·5 ...	4 milliams.
$e =$	0 ...	·2 ...	·75 ...	1·09 ...	1·2 volt.
$r =$	0 ...	11·2 ...	70 ...	202 ...	300 ohms.

This is with E and R constant, and pressure varying.

Now, keeping the contact at constant pressure, and varying the current, if the pressure be not too light, the deflection keeps steady (*i.e.*, with a particular E and R), but when very light, care is required that the contact does not vary much during a series of observations; so that it should be repeated backwards and forwards two or three times to see if consistent results are obtained, all anomalous series rejected, and only those chosen which give nearly the same result on returning to the same E and R. A good series was the following:—

Contact out	20½° ...	35° ...	45° ...	52° ...	56°
„ in	13° ...	25° ...	36° ...	44° ...	50°

These give

$c =$	3·4 ...	7 ...	10·9 ...	14·4 ...	17·8 milliams.
$e =$	·57 ...	·93 ...	1·09 ...	1·25 ...	1·16 volt.
$r =$	166 ..	133 ...	100 ...	87 ...	65 ohms.

c is, of course, the current corresponding to the lower deflection. Very roughly, the apparent resistance varies inversely as the square root of the current. No particular importance can be attached to the figures as regards exactness, for it was a very light contact (and therefore somewhat variable), in order to get a good fall of deflection, which is necessary, because 1deg. makes a considerable difference when the fall is small.

The work done by the current at the contact is ec, or rc^2, or $e_1c + r_1c^2$, if e_1 and r_1 are the real back E.M.F. and resistance at the contact. In the above case we find

$$ec = \cdot0019 \ldots \cdot0065 \ldots \cdot0118 \ldots \cdot0180 \ldots \cdot0206$$

The loudness of the sound given out by the telephone is not proportional to the work done at the contact; for if so it would be a maximum when $e = \frac{1}{2}E$, which is not true. In the case previously mentioned (varying pressure), $e = \cdot8$ E gave the loudest sound, just before breaking, and there is never any falling off except with "bad" contacts. With "good" contacts the sound is always greatest with the least current, provided it be continuous (the battery being of course kept the same), and its intensity is roughly proportional to e, except when e is above $\frac{1}{2}E$, for in the later stages the sound increases much faster than e.

Thus, if we adjust two similar contacts carefully to the same resistance (both planes on middle of board and points on separate springs), and then put them in series, the sound is nearly doubled if e is, say, below ·2 E for each contact, and we find that the back E.M.F. of the two is a little less than the sum of the separate E.M.F.'s, and the resistance of the two not much greater than the sum of their separate resistances. But if e for each contact is greater, say ·5 E, the sum of the E.M.F.'s shows a large falling off, and the sum of the resistances a large increase, and the sound is much less than double that of either.

If we have six similar contacts, each by itself giving the same resistance and sound, putting them in series increases the sound up to, say, three contacts, after which there is little perceptible increase. The current falls a certain extent on adding a fresh contact, but comparatively much more for the later additions than for the earlier. This may be understood by remembering that every contact added reduces the current, and that the resistance of all of the contacts increases simultaneously, and the more so as the current gets smaller. The more sensitive the contacts are, the less advantage there is in putting them in series.

When two contacts are unequally strong, and e is small, they add their effects, both as regards e and the sound. Thus $e_1 = \cdot17$ E, $e_2 = \cdot22$ E; $e_1 + e_2 = \cdot36$ E. Even if e is great for one and small for the other, there is usually a slight increase, or, at any rate, no decrease. If both are made as sensitive as possible, and as equal as possible, putting them in sequence usually increases the sound very little, but this varies according to the resistance of the circuit, on which depends the amount of fall of current on inserting the second contact (the first being already in).

Thus $e_1 = e_2 = \cdot6$ E; $e_1 + e_2 = \cdot81$ E.
$e_1 = \cdot61$ E; $e_2 = \cdot16$ E; $e_1 + e_2 = \cdot67$ E.
$e_1 = \cdot33$ E; $e_2 = \cdot38$ E; $e_1 + e_2 = \cdot59$ E.

On the whole, I found that the calculated value of e was a sort of guide, though not by any means a perfect one, to the intensity of the microphonic action. Sensitive contacts in series require separate examination in turns (by short-circuiting all except one) occasionally, to see that they keep steady. To go by the apparent resistance is very misleading.

But there is also the battery E.M.F. to be considered. The loudness appeared to be about proportional to the number of cells used, from 1 up to 5, with circuit resistance 150 ohms; so that the product Ee would be roughly proportional to the intensity of the sound, or otherwise proportional to the product of the current without the contacts into the fall of current on inserting them. This is true in a large number of cases, but must not be carried to extremes. Thus if one contact brought deflection from 42deg. down to 10deg. with one cell, putting it in sequence with a similar one brought deflection down to 5deg. or less, but with no increase of loudness, in fact a slight decrease; whereas in making the same experiment with 5 cells there was a slight increase. It was also verified many times that if two contacts adjusted equal in the first place, and then put in sequence, bring deflection down to 10deg. (with 1 cell), there is less sound than with either of them alone when adjusted so as to cause the same fall of current. Also, with many contacts in sequence, the sound ultimately decreases, the later additions having apparently much higher resistances than the earlier; the sound increases by addition of two or three, is then about constant with one or two more (all separately giving good sound), and finally decreases on further additions being made. Now here e, calculated for the whole as for a single contact, continually increases, although it becomes practically constant, because the reduction of current for, say, the 6th contact, although it may be considerable compared with the current already reduced by the first five, is quite small compared with the original current.

Contacts in parallel are behave, in the main, as might be expected from the relation between e and the current passing observed in the case of a single contact. The total current is always increased by putting two contacts abreast; *i.e.*, it is greater than through either of them when the other was disconnected, and this is true whether the contacts are separately equal or not. As for the sound, it is never increased, and is generally reduced. If the contacts be unequal, the joint sound is intermediate between their separate sounds. When one is very weak, it shuts up

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the other, however good it may be, which is sufficiently plain, because nearly all the current goes through the weak one. Should there be a difference in character in the sound of the contacts taken separately, such difference will be also recognisable to a certain extent when they are put abreast. Otherwise there is simply a weakening of intensity, unless both are in a very sensitive condition, in which case there is little perceptible difference acoustically between A and B singly and A and B in parallel arc. Now in this last case the current through each is halved when they are put abreast, which involves a reduction in e (or larger increase in r), and at the same time the total current is increased.

Owing to the unknown real resistance, it is desirable to make contacts exactly equal first, before putting them abreast, so that we know that the current goes half through each, whatever their resistance may be. If they could be regarded as battery cells of constant resistance and E.M.F., observations of the fall of current in sequence and abreast and cut out would allow us to reckon the real resistance. But there is no harmony in the results. Four deflections, taken in all possible pairs, gave for the resistance of a single contact from 32, through 42, 46, 55, 61, up to 76 arbitrary units.

On the other hand, calculating e from the results and comparing with the corresponding current, and making allowance for the halving of current when abreast, a fall of e with reduced current was obtained, similar to that observed with a single contact on varying the external resistance.

In concluding this abstract, I will merely add that a great deal of patience is necessary when working with very light contacts, and that when combinations are made, something more than patience is required, and many precautions must be taken, to be found by experience, else very contradictory results may be arrived at.

ON THE ELECTRICAL RESISTANCE OF CARBON CONTACTS.*

BY SHELFORD BIDWELL, M.A., LL.B.

The experiments described in the paper were undertaken with the object of investigating the changes of resistance occurring in carbon cantacts under various conditions.

A short movable carbon rod was placed across, and at right angles to, a similar rod, which was fixed in a horizontal position, and arrangements were made for varying and accurately measuring the pressure of the one upon the other; for varying and measuring the current passing through them; and for measuring the resistance at the points of contact. The following are the most important results arrived at:—

1. *Carbon Contacts.*—Changes of pressure produce proportionately greater changes of resistance with small pressures than with great pressures. Thus, when the pressure was increased from ·25 to ·5 grammes, the resistance fell from 16·1 to 11·8 ohms, the difference being 5·1 ohms; whereas, when the pressure was increased from 25 to 50 grammes, the resistance fell from 2·1 to 1·8 ohm, the difference being only ·3 ohm.

Changes of pressure produce proportionately greater changes of resistance with weak currents than with strong currents. Thus when the pressure was increased from ·25 to ·5 gramme, the resistance fell from 9·27 to 8·45 ohms with a current of ·1 ampere, and from 25·50 to 17·75 ohms with a current of ·001 ampere.

Changes of current produce proportionately greater changes of resistance with small currents than with large currents, and with light pressures than with heavy pressures.

When the resistance of a carbon contact has been reduced by an increase of pressure, it will, on the removal of the added pressure, rise to approximately its original value.

The passage of a current, the strength of which does not exceed a certain limit, depending upon the pressure, causes a permanent diminution in the resistance (so long, of course, as the contacts are undisturbed), and, the stronger the current, the greater will be such diminution.

When the strength of the current exceeds a certain limit the resistance is greatly and permanently increased (generally becoming infinite). The greater the pressure the higher will be such limit.

Unless special means are adopted for maintaining a constant current the fall in the resistance which attends increased pressure is greater than that which is due to increased pressure alone, being partly due also to increased current.

It is not proved that the diminished resistance which follows an increase of current is an effect of temperature.

2. *Metallic Contacts.*—For the sake of comparison a few experiments were made with metals. The metal principally used was bismuth, which was selected on account of its high specific resistance, but experiments were also made with copper and platinum.

In the case of bismuth, and probably of other metals, with a given pressure the weaker the current the higher will be the resistance. This effect is most marked when the current is small. Thus, with a pressure of ·1 grm. the resistance with a current of ·1 ampere was 2 ohms, with ·01 ampere it was 16·92 ohms, and with a current of ·001 ampere it was 143·3 ohms. With a pressure of ·5 grms the resistance with the same currents as before was 1·45, 1·47 and 3·8 ohms.

The passage of a current, even when very small, causes a permanent adhesion between metallic contacts. This effect had been previously observed by Mr. Stroh.

Increase in the current is accompanied by a fall of resistance, and if the current be again reduced to its original strength, the resulting change in the resistance will be small, and it will in no case return to its original value.

Diminution in the strength of the current is followed by a small fall in the resistance if the metal is clean, and by a small rise in the resistance if the metal is not clean.

Increased pressure produces a greater fall in the resistance with small pressures than with great pressures, and with weak currents than with strong currents.

The resistance, after having been reduced by increased pressure, does not return to its original value when the added pressure is removed.

Reasons for the superiority of carbon over metal in the microphone.—The above observations may, perhaps, furnish an answer to the question, why does carbon give far better results than any metal when used in the microphone? The mere fact that a current causes delicately-adjusted metal contacts to adhere to each other seems sufficient to account for the superior efficiency of carbon. In addition to this phenomenon of adhesion, and probably connected with it, are the facts that metallic contacts, unlike those of carbon, do not even approximately recover their original resistance when once it has been reduced by increased pressure or increased current, unless, indeed, complete reparation occurs; and even the initial effect of pressure upon resistance is in general much more marked with carbon than with metals.

Lastly, there is the fact that in the case of carbon pressure and current act in consonance with each other; pressure diminishes the resistance, and in so doing increases the strength of the current, and the current thus strengthened effects a further diminution in the resistance. In the case of metals, on the other hand (or at least in the case of clean bismuth), pressure and current tend to produce opposite effects. The resistance is diminished by pressure, and the current consequently strengthened; but by reason of the increased strength of current the resistance is *higher* than it would have been if the current had remained unchanged. The effect of this antagonism is not very great, but it seems sufficient to give a material advantage to carbon.*

The paper contained fifteen tables, four curves, and three diagrams, illustrative of the apparatus used.

* Abstract of a Paper read at the Royal Society, Feb. 1, 1883.

[* In April, 1882, the author communicated this observation to Mr. Preece, who referred to it in a paper read at the Southampton meeting of of the British Association on "Recent Progress in Telephony."]

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PRELIMINARY NOTE ON A THEORY OF MAGNETISM BASED UPON NEW EXPERIMENTAL RESEARCHES.

BY PROFESSOR D. E. HUGHES, F.R.S.*

In the year 1879† I communicated to the Royal Society a paper "On an Induction Currents Balance and Experimental Researches made Therewith." I continued my researches into the molecular construction of metallic bodies, and communicated the results then obtained in three separate papers‡ bearing upon molecular magnetism.

To investigate the molecular construction of magnets required again special forms of apparatus, and I have since been engaged upon these, and the researches which they have enabled me to follow.

From numerous researches I have gradually formed a theory of magnetism entirely based upon experimental results, and these have led me to the following conclusions:—

1. That each molecule of a piece of iron, steel, or other magnetic metal is a separate and independent magnet, having its two poles and distribution of magnetic polarity exactly the same as its total evident magnetism when noticed upon a steel bar-magnet.

2. That each molecule, or its polarity, can be rotated in either direction upon its axis by torsion, stress, or by physical forces such as magnetism and electricity.

3. That the inherent polarity or magnetism of each molecule is a constant quantity like gravity; that it can be neither augmented nor destroyed.

4. That when we have external neutrality, or no apparent magnetism, the molecules, or their polarities, arrange themselves so as to satisfy their mutual attraction by the shortest path, and thus form a complete closed circuit of attraction.

5. That when magnetism becomes evident, the molecules or their polarities have all rotated symmetrically in a given direction, producing a north pole if rotated in this direction as regards the piece of steel, or a south pole if rotated in the opposite direction. Also, that in evident magnetism, we have still a symmetrical arrangement, but one whose circles of attraction are not completed except through an external armature jointing both poles.

The experimental evidences of the above theory are extremely numerous, and appear so conclusive, that I have ventured upon formulating the results in the above theory.

I hope in a few weeks to bring before the Royal Society the experimental evidence which has led me to the conclusions I have named; conclusions which have not been arrived at hastily, but from a long series of research upon the molecular construction of magnetism now extending over several years.

THE B.A. UNIT OF RESISTANCE.

BY LORD RAYLEIGH, F.R.S., AND MRS. H. SIDGWICK.§

The experiments described in the present paper were carried out during the spring and summer months of last year at the Cavendish Laboratory, and are divided into three distinct series. In the first and second series the induction coils were situated nearly in the plane of the revolving disc, as in Lorentz's original use of the method, the difference between the two series relating only to the speed of rotation, which was varied in the proportion of 10 : 16. The third series presents a point of novelty in that the induction coils were separated from the disc to such a distance as to render the accuracy of the result practically independent of the mean radius of the coils.

The small resistance, traversed by the battery current, to which the terminals of the galvanometer branch are connected, was obtained indirectly by a method of shunting. Thus in the first series, the principal part of the battery current passed on one side through two unit coils, placed in multiple arc, and equivalent to $\frac{1}{2}$, and only a comparatively small remainder through a second branch, composed of two coils in series, of values 10 and $\frac{1}{10}$. The terminals of the galvanometer branch were connected with the extremities of the $\frac{1}{10}$, and the difference of potentials between them, due to the primary current, was thus reduced to that which would be required to drive the current through a resistance of $\frac{1}{200}$.

From the first series—

$$1 \text{ B.A. unit} = \cdot98674 \times 10^9 \text{ C.-G.-S.}$$

From the second series—

$$1 \text{ B.A. unit} = \cdot98669 \times 10^9 \text{ C.-G.-S.}$$

From the third series—

$$1 \text{ B.A. unit} = \cdot98683 \times 10^9 \text{ C.-G.-S.}$$

As a mean we take—

$$1 \text{ B.A. unit} = \cdot98677 \times 10^9 \text{ C.-G.-S.}$$

With use of the ratio between the mercury unit and the B.A. unit, found by us (*Proc. Roy. Soc.* May, 1882) this gives—

$$1 \text{ mercury unit} = \cdot94150 \times 10^9 \text{ C.-G.-S.}$$

or, which is the same thing, the ohm is the resistance of a column of mercury at 0° Cent., whose section is one square millimetre, and whose length is—

1062·14 millimetres.

The very close accordance between the result of the present investigation and that obtained by the method of the revolving coil (·98651), and by Glazebrook (·98665), using another method again, leads us to hope that no error of importance can have escaped detection.

The appendix is devoted to a record of experiments having for object the determination of the absolute pitch of a certain tuning fork, which has served as the standard of time throughout all our work upon this subject. It is believed that the method employed is worthy of attention, and may be useful to other physicists.

CORRESPONDENCE.

STATIC ELECTRICITY AND QUANTITY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Opinions differ, and will continue to differ, so also will the aspects of natural truths, and the modes of expressing them. Mr. Von Tunzelmann (p. 278) criticises my views from his own point, and I am obliged to him or any one who will, by so doing, enable me to examine all points, because I am conscious how much there is to learn. But I do not care to discuss a single incidental portion of a complete idea, and especially I decline to discuss it on the mystical, artificial principles which I protest against. Whether Mr. Von Tunzelmann cares to examine my complete work or not is a matter for himself; the fact that readers have taken up an edition of 2,000, with scarcely any advertising, justifies me in believing that in my mode of dealing with electrical matters I have met a want. As to the particular subject, opinions differ very much. I received a letter from America, from a gentleman unknown to me, beginning "Permit me to thank you for the instruction your article 'The Inductive and Conductive Circuits,' contained in *The Electrician* for December 23, ultimo, has afforded me. It is just the style suited to the wants of those experimenters who deem life too short to unravel the mysteries of many so-called standard works of the present day."

I expected Mr. Von Tunzelmann to explain to me that current is not a velocity; in fact, I used the particular expression intentionally. In common sense, current is the velocity, or rate of unit transmission. We may express that in a variety of ways, and among others in the form used in the system of "dimensions," which he prefers.

I must correct Mr. Von Tunzelmann as to "Mr. Sprague's

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* Abstract of a paper read before the Royal Society, January 27.

† *Proceedings* Royal Society, vol. 29, p. 56, 1879.

‡ *Proceedings* Royal Society, vol. 31, p. 525; vol. 32, pp. 25, 213, 1881.

§ Abstract of a paper read at the Royal Society, entitled "Experiments, by the Method of Lorentz, for the Further Determination of the Absolute Value of the British Association Unit of Resistance, with an Appendix on the Determination of the Pitch of a Standard Tuning Fork."

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complacent opinion that Clerk Maxwell was gradually adopting his views." I said nothing of the kind. I said he was gradually adopting views "the same as those I endeavour to sustain." Those views are in the air—held by a large school of electricians, and gradually influencing the whole body. All I can claim in the matter is that I have set them forth in a book, of which one of my reviewers said, "He has boldly accepted the doctrine germinated by Faraday, and *slowly creeping into scientific belief*, that electricity and magnetism are due to the polarity of molecules, and that we are to search for it, not so much in the conductors that bring it within the cognisance of our senses as in the insulating media that are inseparable from its manifestations."

As to the change in Clerk Maxwell's views, it is very evident in his posthumous work, and the general change which is occurring is manifested in every recent book, where we always find two inconsistent explanations given of the phenomena. One thing is clear, Clerk Maxwell says nothing of electric repulsion, but gives what amounts to the same explanation as my own. Further, I quote his own statement:—"I made use of methods I do not think best in themselves, but without which the student cannot follow the investigations of the founders of the mathematical theory of electricity. I have since become more convinced of the superiority of methods akin to those of Faraday, and have, therefore, adopted them from the first." That is just my own position. I say that the purely artificial electricity invented by mathematicians involves an artificial treatment, and that the object of my study is electricity such as it operates in nature, not on the black board of a lecturer's class room.

As to others, we find writers defining unit quantity as that which repels a similar quantity at unit distance with unit force, which is not true, unless we add, under fixed conditions of surroundings and in a specified dielectric, the air. They give elaborate explanations about distribution upon a single surface, all of which are untrue, and which they have to qualify by the statement, "provided they are at a great distance from surrounding surfaces." They talk constantly about putting a charge of electricity upon an isolated sphere, and about the capacities of spheres varying as their radii. In fact, through all their explanations they treat electricity as if it were a single matter, capable of being put upon a single surface. Then they turn round and explain that all these phenomena are entirely dependent on the actions in the dielectric, and that electricity is a dual action setting up stresses in this dielectric. Now, this latter is the truth they are really gradually taking up, while they cling to the older explanations and formulæ inconsistent with it.—Yours, &c.,

J. T. SPRAGUE.

PROPERTIES OF TEMPERED STEEL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to Professor Hughes's interesting paper on the properties of tempered steel, I would venture to ask him if he has tried what results are obtained when steel, which has been perhaps previously dead hard, is heated so as to be just luminous when held in a dark corner, and then quenched. Treated thus, it will be found to be quite soft. Now, to make it dead hard, it must have been at a much higher heat than this just luminous state—bright, cherry red, in fact—and this lower heat would be insufficient to alter the "alloy" formed at the higher temperature, as I read Professor Hughes's paper. I do not think this mode of softening is generally known. Almost daily it will be found useful. The largest piece I have tried, and quite successfully, was 2¼in. diameter by 1in. thick.—Yours, &c.

February 5th, 1883. W. T. F.

THE ACTION OF MICROPHONES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to ask Mr. Smillie if he still thinks that the continuity of the contacts does not vary when spoken to, as he said in his first letter? If so, he can (providing his idea be correct) make his Blake speak by closing the circuit through S, C, and B, instead of carrying it through P and R. His instrument will not be altered by this means, so he will be able to adjust it to any degree of pressure he may choose. He says he understood me before, but I cannot think that he did. Perhaps he will be good enough to tell us what *he* means when he speaks of a closed contact. Would he consider it to be properly closed until the fullest amount of current was obtained? The statement in the first letter shows that he considers the contacts to have nothing to do with the matter. I think if Mr. Smillie will pay strict attention to my plan he will be able to prove the thing right or wrong. If he finds himself wrong he will only be in the same position that better men than himself have been in; if he is right, it will be for his opponents to give way. If in writing Mr. Smillie would think a little more of the subject, and a little less of useless expressions, the reader would be the gainer by the change.—Yours, &c., J. RATHBONE.

5, Prospect-place, Treorchy, South Wales.

SELF-REGULATING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

(TRANSLATION.)

SIR: In your article on "Self-regulating Dynamo Machines" (*The Electrician*, Jan. 20) you very rightly remark that if A B invents something, but keeps that something secret, some one else, C D, may also invent the same thing; but if A B has taken out a patent, then C D's patent is invalid, and the latter has lost his money, and what is perhaps worse, the time occupied in studies, which can be credited to A B alone. It is for this reason that I beg you to be good enough to insert my letter in the next number of *The Electrician*.

If we employ two wires for the electro-magnets of a dynamo, the one as a shunt and the other for the main current, we can then connect up in three different ways, as I have shown in Fig. 1, or, as in Fig. 2, in an intermediate way.

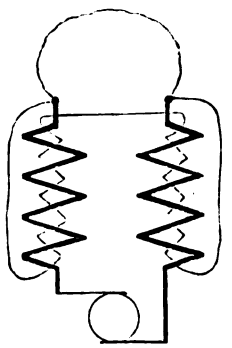

FIG. 1.

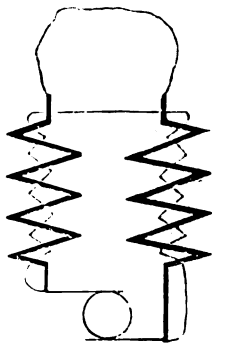

FIG. 2.

Now, I have shown in my patent that in order to obtain the required regularity in the case of a variable number of machines in multiple arc, it is necessary to employ the arrangement shown in Fig. 1; and, in order to have a constant current, we must employ the arrangement shown in Fig. 2, whilst the intermediate arrangement may be used in special cases, such as for running a machine above its normal working power, or for sending a current to a great distance from the machine. You will find this in an extract from my German patent, which I send you herewith privately, and not for publication. You are aware that no one is permitted to make public an invention which he wishes to patent in Germany before it has been published by the Patent Office. I cannot, therefore, say more at present, but I reserve myself the right of publishing later on the methods employed in the construction of my machines, as well as several other means for regulating the current, such as are described in my patent, together with the results of experiments made.

I would only remark that if differences of 6 per cent. have been obtained with the *soi-disant* "self-regulating" machines, as described in an article which has appeared in your paper, it is because the arrangement shown in Fig. 2 has been

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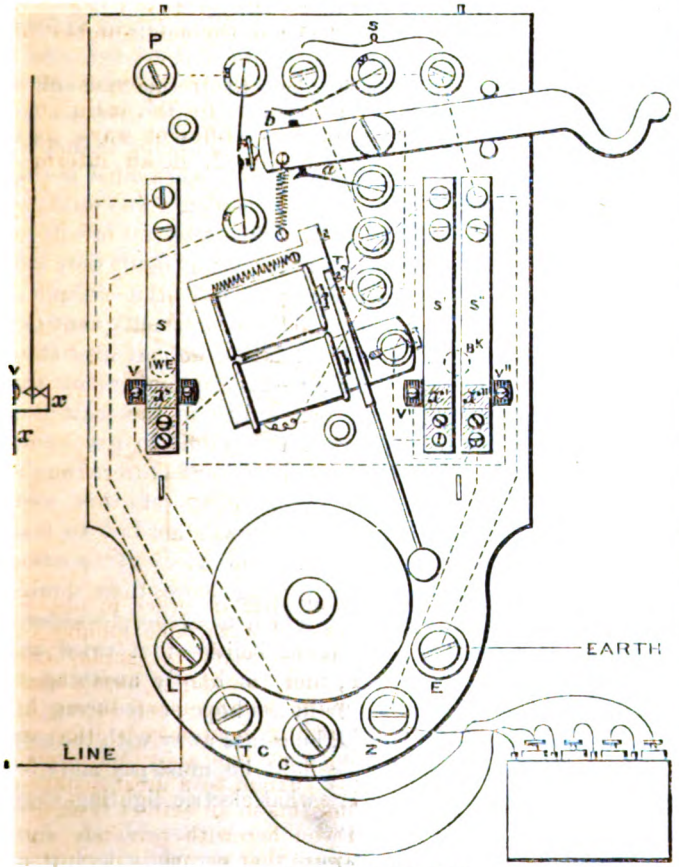
employed, whereas the arrangement shown in Fig. 1 should have been used. These two arrangements, which appear at first sight to be similar, are really very different, and I believe I am the first who has shown in a definite way which should be employed in any case.

If I am a little late with this letter it is not because my invention is of recent date, since I had already applied for a patent in Germany, and other countries also, before the first article on this subject had appeared in *The Electrician*. I did not think that there was any necessity for provisional publication of the matter, but you have convinced me that it is useful "to take some members of the technical press into confidence, and put out of question once and for all claims to priority, by a suitably worded paragraph which records but does not enter into details." *Vide The Electrician*. January 6.—Yours, &c., C. L. R. E. MENGES.

NEW TELEPHONE SWITCH BELL.

DESIGNED BY MAGNUS VOLK.

This bell offers the advantage that a call or answer signal can be given whether the sender's telephone is on the hook or not. It is also fitted with two ringing buttons, black and white. When the subscribers are through, a polarised annunciator in the exchange is connected in a derived circuit from the subscribers' lines, so that they can leave their instruments, and call each other up as often as they please by using the white button; when they have finished the black button is pressed, thus causing the annunciator to drop, giving the "cut-off" signal.



New Telephone Switch Bell

Terminal P is connected to one of the primary terminals in transmitter, and the other primary terminal in transmitter to E.

The terminals S are connected to secondary terminals in transmitter; the other connections are as shown.

In calling up or answering a subscriber the button W E is pressed. This brings the spring S into contact with plate v, connected to terminal C. From spring S the current goes direct to line.

In calling up the exchange or giving the "cut-off" signal, the button B^k is pressed. This presses both the springs S' S'' back; S' into contact with plate v', which is connected to x'' and Z, and S'' into contact with v'', which is connected with v, and so to C.

The path of the current is now as follows:—From C to plate v, plate v'' and spring s'' to E, returning to terminal L, spring S, top bracket x, spring S', and plate v' to Z.

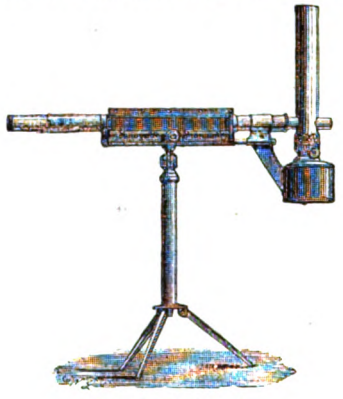
The passage of the incoming ringing current is as follows:—Terminal L, spring S, bracket x, spring S', bracket x', contact post in bell (when the telephone is on the hook the contact a is broken, and b closed), bell coils to hook lever centre, contact b, and then to E, as shown.

When the telephone is in use the current follows the same path as far as the contact post, when it goes through contact a to lever, thence through telephone to terminal S and transmitter secondary, returning by second terminal to E, as shown.

The above apparatus was designed for Mr. Haworth, the electrician of the Lancashire and Cheshire Telephone Company, he sketching his requirements for Mr. Volk.

MR. SABINE'S PHOTOMETER.

Mr. Sabine has lately constructed a new photometer, which is shown in perspective in the figure. The stand supports a straight tube, at one end of which is an eye-piece and at the other a paraffin lamp. The middle portion of the tube is cut away, and has slipped over it a collar, to which a frame is attached, carrying a wedge of neutral tinted glass, adjustable by a rack and pinion. Inside the collar is fixed transversely a disc of ground opal glass, which the paraffin flame illuminates to a known degree. This disc constitutes the field of comparison, the illumination of which is adjustable by means of a series of diaphragms of known aperture placed at the end near to the paraffin flame. At the side between the wedge and the collar which carries it is a narrow pane of ground opal glass, just behind which a small mirror is fixed at an angle of 45deg. to the axis of the tube. This mirror is supported from the centre of the transverse opal disc in such a manner that the support is hidden from the observer by the mirror itself—an arrangement which ensures the apparent juxtaposition of the illuminated surfaces which have to be compared. The light to be measured is placed on the right-hand side of the photometer,



Sabine's Photometer.

and the collar, with the wedge turned so that the light falls normally upon the face of the wedge, passes through the wedge, through the pane of opal glass, and is incident upon the mirror, which reflects a portion of it to the eye of the observer. The wedge is shifted to interpose a greater or less thickness of the absorbing medium, till a balance is obtained, that is until the apparent illumination of the mirror is equal to that of the field of comparison, in the middle of which it is seen. If the range of the wedge is insufficient to admit of this, the degree of illumination of the field is altered by means of the diaphragms, and the wedge then adjusted.

The employment of glass wedges from photometric comparisons is not new, having been already used by both Xavier de Maistre and Quetelet; but no practical photometer, based upon this method, has hitherto been constructed. The employment of diaphragms for increasing the range of the wedge is found to work well, and to enable the observer to adjust the illumination of the field with exactitude; the bright part of the paraffin flame being, of course, kept opposite to and so as to well cover the diaphragm aperture.

A table is constructed giving for each position of the wedge and for each diaphragm the value in standard candles of any light placed at one metre distance from the instrument; and if the light be placed at any other distance the number in the table has simply to be multiplied by the square of the actual distance in metres.

For ascertaining approximately the amount of light which passes through any given coloured glass—such, for example, as orange glass—the eye-piece is furnished with a rotary disc containing small panes of white and different coloured glasses, either of which can be interposed at pleasure.

This photometer is made by Messrs. Elliott Brothers in two forms, one for use as a portable photometer, as shown in the figure, and the other on a more solid stand for laboratory purposes.

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THE ELECTRICIAN.

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All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

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MORE GAS.

Whatever angry feelings may at first have been aroused among the owners of gas property by the intrusion of the electric light must now, we should imagine, give place to sentiments nearly akin to gratitude. The scare which temporarily depreciated the price of gas shares to about half their market value has been followed by an equivalent rise and a steady tone which is not likely to give way to panic again in a hurry. But this is not all; the competition of the electric light has created a demand for better illumination, and this means the consumption of more gas. The public, we have heard it stated, have become quite demoralised in the matter of street lighting, and having tasted the luxury of a well lighted thoroughfare, will not again submit to anything less luxurious in place of it. We are not in the secrets of the gas manufacturers, but nobody can walk along either of the two great footways which lead from the City to the West End without feeling perfectly convinced that the consumption of gas must have greatly increased since electricity essayed to extinguish it. The gas corporations are not likely to be making this great display experimentally, or at a loss, as is spitefully alleged of one or two electric lighting companies; and we may, therefore, conclude that the receipts of the former have of late been greatly augmented. For this they have to thank the electric light, and we hope they are grateful.

The exhibition of gas lighting appliances at the Crystal Palace is another boon which the gas companies owe to the electric light. Nominally it is a competitive exhibition between the two systems of lighting, the old and the new; but in reality the gas people have the field almost all to themselves, some well known electric lighting engineers even going so far as to exhibit gas lighting appliances only, and not their electric lighting inventions. The few exhibits of electrical illumination on view are of little account and are not calculated to depress the spirits of shareholders in the old companies. Whether this is a wise piece of self-denial on the part of the electric lighting interests time alone will show; certain it is the gas interests are just now in the ascendant at the Crystal Palace, and nobody can blame them for making the most of the occasion. There are several useful lessons to be learnt at this exhibition, however, which those who are interested in the future of electric lighting may profit by, and we will mention a few of them.

First of all, gas is here at its best. We see what it can do. Not that anybody doubted we could have more light by consuming more gas; but the gas engineers appear to have thought it necessary to remove the doubt if it existed. At a profligate expenditure of gas, they have lit up this vast edifice splendidly. But this is all. There is no evidence of economy in the general arrangement, the aim being to display great lights; and the impression left on one's mind is that the exhibitors only wanted to convince us that, if we would pay for a big light, we could have it. This tells in favour of electricity, for if the public will pay for a big light they can certainly have electricity as cheaply as gas—the cheapness being on the side of gas when small lights or small quantities of light are in question. In this relation we may also state that the devices for economising consumption are of the poorest, testifying to general incredulity in the matter of economy, and to the willingness of the public to pay handsomely for what it likes. Gas manufacturers ought to be the best authorities on a point of this sort, and electric lighting manufacturers will not fail to take note of it. Beyond the curious device of putting two gas flames together, and getting more than double the light out of them—a device which most people seemed to regard as an attempt to make believe that twice one are three—beyond this, we say, there is hardly anything to encourage a careful housekeeper in the hope of reducing his gas bill. On the whole, indeed, he comes away with the conviction that if he wants a better light he must pay more for it, which is, at present, precisely what electric lighting engineers are saying.

Secondly, in the matter of candle-power, there is just as much looseness of statement here in respect to gas as there has been anywhere with regard to electricity. Candle-power we suspect in many instances is estimated by the known consumption of gas, which is much the same as measuring an arc light by the horse-power employed to maintain it. Some of the monster lights which have been much talked about certainly do not show here to advantage. They are eminently calculated—one at least was so—to illuminate a ceiling, or to set it on fire; but as for lighting anything below they do not even make the attempt. They are, in fact, gas furnaces, with

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all the objections of redness, an obstructive burner, and the central mass of the flame giving off no light worth speaking of. The candle-power conspicuously marked on lamps such as these will only confirm public suspicion as to the illusory character of candle-powers in general. In this respect gas is evidently as great a sinner as its rival.

Of the street lamps on view there are several of considerable merit as regards illumination, and from the design of which electric lighting engineers might learn a wrinkle or two. Especially it is noticeable that artistic taste has been bestowed on these lamps; they are agreeable to look upon as well as useful, a point which has been not only overlooked but rudely defied by some electric lighting engineers. The public may consent to have their streets temporarily disfigured for an experiment, but for permanent installations beauty as well as utility must go together if the public are to be won over. To this fact the gas engineers appear to be fully alive, and our clients would do well to follow their example.

On æsthetic grounds, as well as on some other to be referred to immediately, we cannot refrain from contrasting the two classical courts, illuminated the one by gas the other by electricity. Both are specialties. The latter makes a merit, so it would seem, of employing a naked light which nobody can endure to look upon intentionally, and which it would really be a charity to prevent being seen accidentally; the other has its lights naked also, partly to show their purity, partly, no doubt, to enhance the general effect. The fittings of these are very chaste, and in keeping with the architecture; the fittings of the light in the other court cannot be seen for the dazzle, and probably they are not worth examining. The general effect is unmistakably in favour of gas, though the volume of light, and perhaps its cost, may be all on the side of electricity. For this result the proprietors of the electric light have only their want of taste and judgment to blame.

The gas light just referred to was the perfection of lighting—save in one particular; it costs some trouble, and the public we know will not take trouble. The purifying medium has to be replenished frequently, and some patience exerted before it acts. These, we think, are fatal objections, and we mention them as applicable to electric lights that require attention from private users. "How would the servants be able to dust those globes?" was the very practical question of a lady whom we overheard interrogating the exhibitor of some meretricious lamps buried in fragile inutilities of glass and china. She shook her head when told that the globes could be removed quite easily. Probably the lady housekeeper has her own view as to what is easy, and she certainly ought to be consulted.

Lastly, the condition of the atmosphere at the Crystal Palace is proof that a great illumination of gas cannot be obtained without serious danger of one sort or other. Ventilation is obtained only by opening every available window, and the discomfort occasioned by the consequent draughts is so great that the attendants who have to remain in one spot and uncovered are objects of general pity. This exhibition, if encouraging to the gas interests, should be very instructive to the promoters of electric lighting.

ANSWER TO CORRESPONDENT.

P. A.—The Morse code is in use in France.

TECHNICAL SCHOOLS.

I.

The School of Telegraphy and Electrical Engineering.

During the past two years many parents, anxious to find an opening for the future work of their sons, have looked with favour upon the prospects of electrical engineers. We have received a large number of letters—and, indeed, are almost daily receiving letters—asking for advice and suggestions as to where a youth can obtain the fundamental information which ought to constitute the groundwork of an electrical engineer's education. So far as we know the following colleges and schools profess to give this kind of technical information:—

COLLEGES.

Cavendish Laboratory, Cambridge	Professor Lord Rayleigh, F.R.S.
Glasgow University	Professor Sir W. Thomson, F.R.S.
King's College, London	Professor W. G. Adams, F.R.S.
University College, London	Professor Carey Forster, F.R.S.
Queen's College, Liverpool	Professor O. J. Lodge, D.Sc.
University College, Nottingham	Professor W. Garnett, M.A.
University College, Bristol	Professor S. Thompson, D.Sc.

SCHOOLS.

School of Telegraphy and Electrical Engineering	12, Princes-street, Regent-street.
Hammond Company's School.	2, Red Lion-square.
Crystal Palace School	Sydenham.
City Guilds' Institute (Professor W. E. Ayrton, F.R.S.)	City Schools, Cowper-street, E.C.
College of Science (Principal, A. Jamieson)	Bath-street, Glasgow.

No doubt there are other places where the student can obtain good tuition, but we can only speak of those we know. Of the schools, the one we have mentioned at the head of this article is the oldest, and, therefore, historically, should be mentioned first. We presume that parents and students are only anxious to obtain a general idea of these institutions, and to be satisfied that they are supplied with the necessary apparatus, and that the work is carried on under sufficiently good lecturers and tutors. With regard to the school under notice we may safely state that the apparatus is ample, and of the most recent construction, and that the lecturing staff is larger than is ordinarily the case with a given number of students. Fig. 1 will give some idea of the interior of the principal work room, which room is sometimes used as a lecture room. The large supply of testing apparatus admits of a good deal of individual work, under the supervision of demonstrators. The work of the school is carried out in two lines, one intended to educate aspirants to various positions in the telegraph world, and more especially, perhaps, in the large cable companies. A large portion of the cable companies' staffs have received their early training in this school. Special apparatus is to be formed for this special work. Thus, with the exception perhaps of Glasgow University, this institution is the only one where an artificial cable is to be found. We believe that almost as soon as Mr. Cromwell Varley, F.R.S., had designed his system of condensers and resistances to represent a cable, the school obtained an artificial cable in order that the students might as nearly as possible work under similar conditions to those which hold in working a real cable. It will be remembered that this school exhibited at the late Crystal Palace Exhibition one of Sir W. Thomson's syphon recorders, an instrument which the necessities of long cable telegraphy has called into existence. It will be gathered from these remarks that the telegraphic department is most complete. The same may be said with regard to the telephonic apparatus. Again, in that branch of electrical science which is now so prominent, the student is not left to verbal description or diagrams in order to get his ideas of a lamp or machine, but has specimens of the more important lamps, &c., before him. These he dissects in order to become acquainted with every part, and with the particular function of each part. He tests the parts—he tests the whole. Fig. 2 shows portions of various rooms, such as the machine room, containing Siemens, Brush, and Gramme machines, the

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chemical laboratory, the room for experimenting with secondary batteries, &c. The latter rooms are used by the more advanced students, and a good deal of original work indicated by the lecturers, or suggested by the students themselves, is carried out, and we hear this branch of the training will be developed to a still greater extent. The senior lecturer, upon whom, indeed, the scientific organisation has devolved since the opening of the school, is Mr. Desmond FitzGerald.

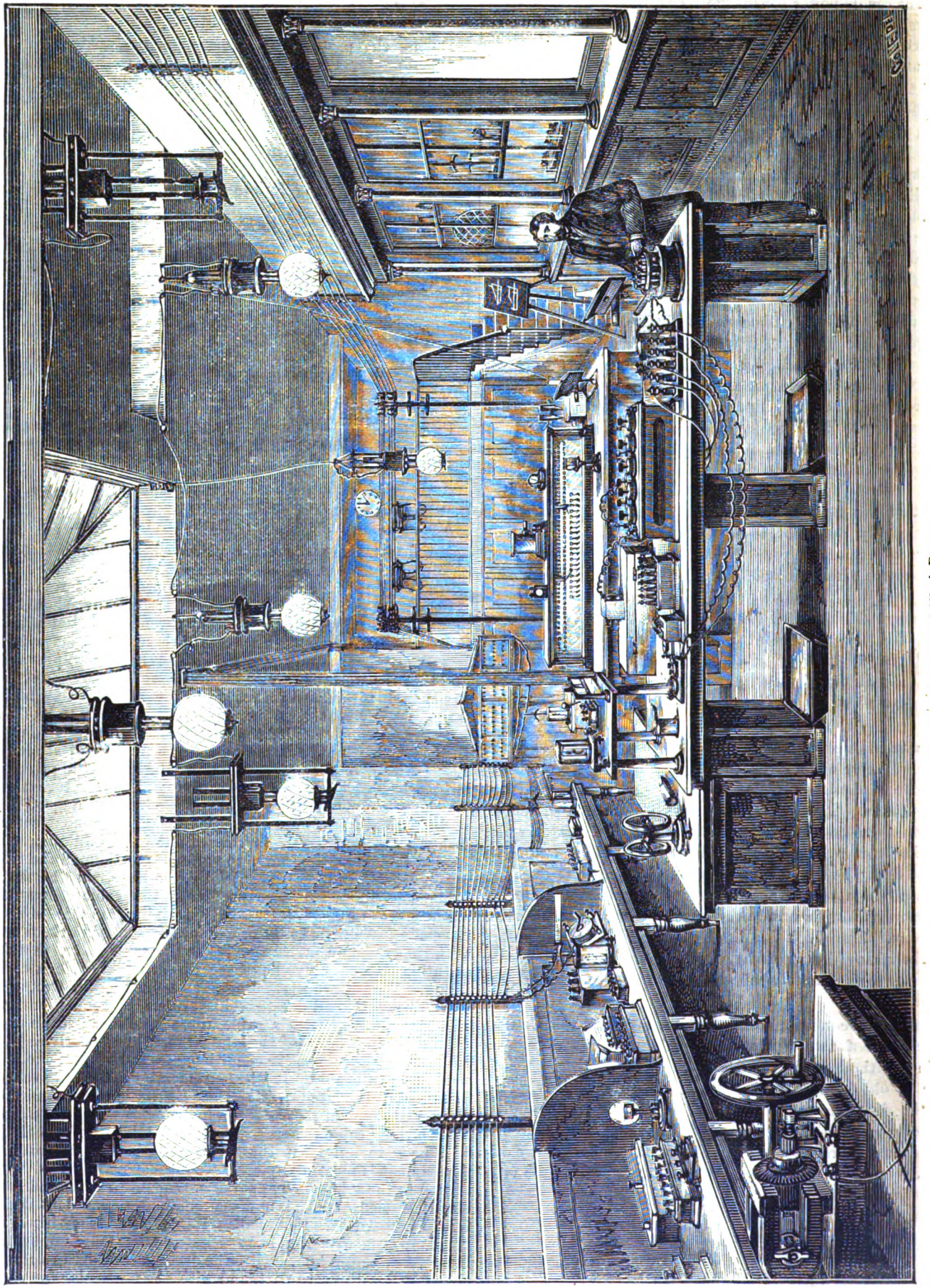

FIG. 1.—The principal Work Room.

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The school was founded by the late Mr. Lundy, and was at first devoted to the training of operators for land lines, but from the first insisted upon the necessity of a theoretical, as well as a practical, training for such as wished to become more than mere automatons. The extension of cable work created a field for a higher class of men, and the development of the electric light holds still greater inducements for men to obtain a more thorough knowledge of electrical theory and

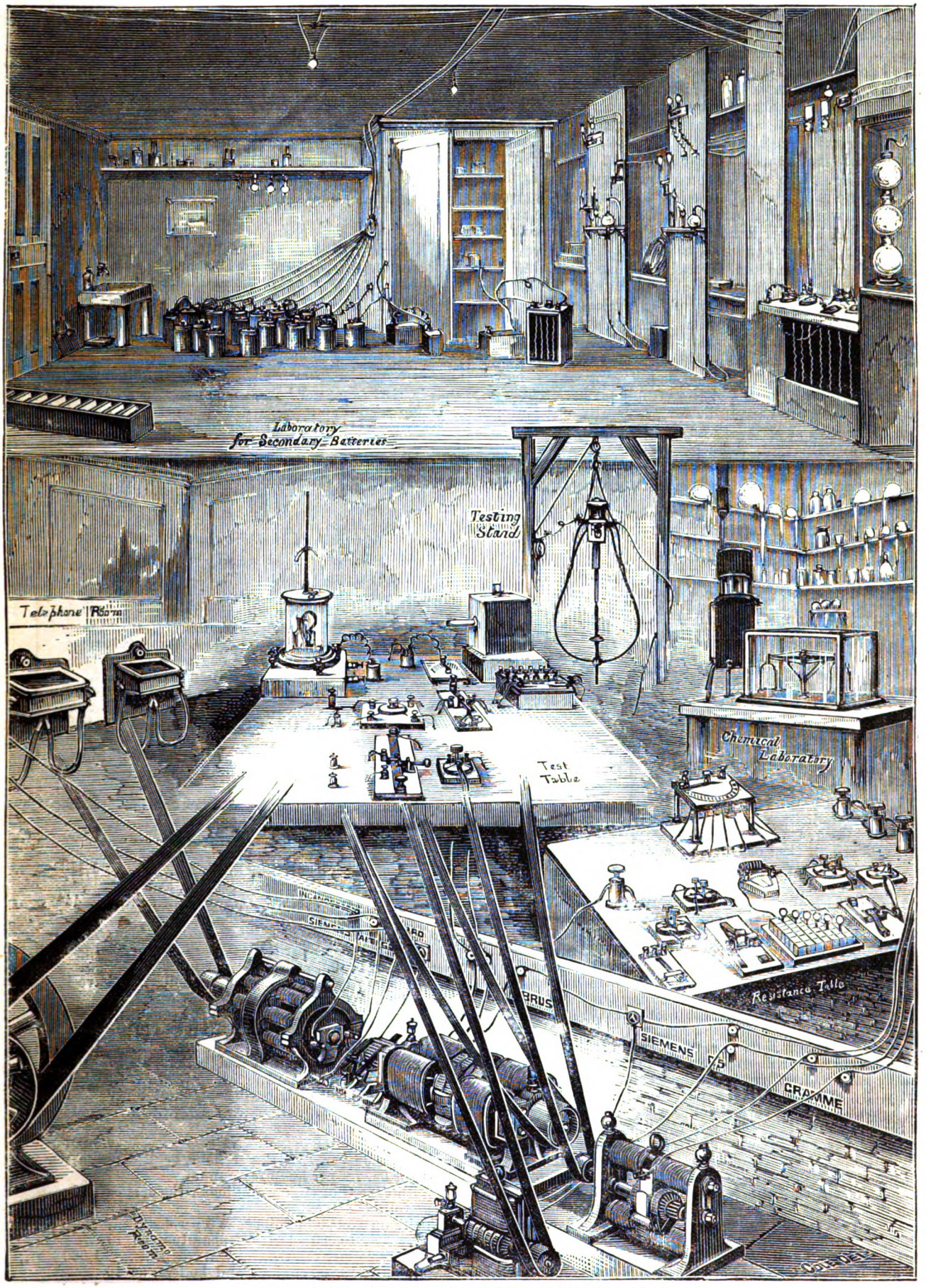

FIG. 2.—Machine Room, Chemical Laboratory, Battery Room, &c.

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practice. The course extends over a period of nine or twelve months, and, besides the practical work, includes lectures on electricity, heat, the steam engine, chemistry, &c., so far as these subjects are calculated to assist the student in his practical work. We have known the school for many years, and we have known personally many of the men trained therein, and perhaps an opinion expressed under these conditions is a little more satisfactory than one by a reporter who rushes over the place and out again, and whose impressions are, we opine, almost valueless. There is no doubt that a strenuous attempt has been made to supply everything that a student can possibly require. The rest depends much upon the student himself. If he means work there is everything in his favour. If he will not work, and is careless and indifferent, he suffers accordingly. A lecturer is not a schoolmaster, nor are these pupils schoolboys, nor can scholastic discipline be resorted to. A number of men from the school have done, and are doing, good work, both in telegraphy and in electric lighting. Our columns can show that some of the students have sufficient confidence in their knowledge to enter the field of literature. In order to obtain an idea of the students' progress, periodical examinations are held, and at the end of their course a certificate used to be—and we suppose is now—given, based upon the result of the examinations. The aim, however, is to prepare the pupils for practical work, and not to cram them with superficial knowledge, that they may pass this or that examination. The general organisation of the school is carried on under the able superintendence of Mr. T. J. Jones, supplemented by that of the secretary, Mr. W. N. Tiddy.

BOROUGH OF SHEFFIELD.

Electric Lighting Act, 1882.—Preliminary Report of Conrad W. Cooke, M.S.T.E. & E.

(concluded from page 281.)

I will now consider the probable cost of working such an installation, inclusive of charges for management as well as for interest on capital. I will divide these charges under four heads, viz.:—

I.—Cost of Production.
II.—Cost of Maintenance.
III.—Cost of Management.
IV.—Interest on Capital.

1. Production.

The cost of production is made up of three principal items:—

1. Cost of Coal.
2. Cost of Oil, Stores, &c.
3. Wages.

Cost of Coal.

Taking the price of engine coal delivered in Sheffield at 7s. per ton, and estimating that the compound non-condensing engines with Lancashire boilers (A) will consume 2·71b. of coal per horse-power per hour, we have an expenditure of £1,582 per annum.

If, however, condensing engines with similar boilers be employed, the cost for production will be less on account of the greater economy of working, they consuming but 2·3lb. of similar coal per horse-power per hour, the cost will therefore be £1,347 per annum.

The saving of coal is, however, to a certain extent, neutralised by the extra cost of maintenance added to a larger interest on capital by reason of the greater prime cost of the engines.

Lastly, by the employment of "Locomotive" boilers—by which a great saving of space is effected, and steam may be got up in the shortest possible time—a still less quantity of coal per horse-power per hour is consumed, being at the rate of about 2lb., but it must be borne in mind that these boilers are not suited for burning ordinary engine coal, but require a more expensive fuel, such as Tanfield Moor or coal of similar quality, costing in Sheffield probably as much as 9s. per ton, and here again the extra capital involved raises the cost of working and the interest to a price which, unless a saving of space be of great importance, hardly justifies the adoption of this class of boiler and engine. The cost of coal in this case would be £1,507 per annum.

Oil Stores, &c.

I now come to that item in the cost of production which refers to oil stores, and this may be fairly estimated at about £4 16s. per week, or £250 per annum.

Wages.

With respect to wages the following staff will be sufficient to work such an installation as is referred to in this report:—

One electrical foreman, at £12 10s. per month	£150	per annum.
Three engine drivers, each at £8 15s.	315	,,
Six firemen, each at £6 10s.	470	,,
One boy, at £1 15s.	21	,,
Total for wages	£956	

Summarising the foregoing figures, we get the following results for the employment of the type of engine and boiler referred to in column A in the tabulated summary of capital:—

Coal	£1,582	per annum.
Oil and stores, &c.	250	,,
Wages	956	,,
	£2,788	

that is to say, ·178 pence per I.H.-P. per hour, *i.e.*, ·022 pence per hour; or 5s. 6½d. per lamp per annum.

Employing type B of engine and boiler, we have the following cost of production:—

Coal	£1,347	per annum.
Oil and Stores, &c.	250	,,
Wages	956	,,
	£2,583	

that is, ·163 pence per hour, = ·02 pence per lamp per hour, or 5s. lamp per annum.

With type C of engine and boiler, the cost of production will be as follows:—

Coal	£1,507	per annum.
Oil, Stores, &c.	250	,,
Wages	956	,,
	£2,713	

that is, ·174 pence per I.H.-P. per hour, = ·022 pence per lamp per hour, or 5s. 6d. per lamp per annum.

II. Maintenance.

The expenses of maintenance of an electric lighting installation are made up of the following items:—

1. Repairs of buildings,
2. ,, electric apparatus,
3. ,, engines and boilers,
4. ,, distributing plant,

and these I would estimate at about 5 per cent. per annum on the first cost respectively of the buildings and distributing plant, and 10 per cent. on that of the electric apparatus and motive power.

Upon this principle of estimation the following will be the cost of maintenance of the installation of type A if engine and boiler be adopted:—

Repairs on £5,000 buildings, at 5 per cent.	£250	per annum.
,, £10,000 electric apparatus, at 10 per cent.	1,060	,,
,, £11,180 engines and boilers, at 10 per cent.	1,118	,,
,, £8,880 distributing plant, at 5 per cent.	444	,,
	£2,872	

which is ·184 pence per I.H.-P. per hour, or ·023 pence per lamp per hour, or 5s. 9d. per lamp per annum.

Employing type B of engine and boiler, we have the following cost of maintenance:—

Repairs on £5,000 buildings, at 5 per cent.	£250	per annum.
,, £10,600 electric apparatus, at 10 per cent.	1,060	,,
,, £15,530 engines and boilers, at 10 per cent.	1,553	,,
,, £8,880 distributing plant, at 5 per cent.	444	,,
	£3,307	

= ·212 pence per I.H.-P. per hour, or ·026 pence per lamp per hour, or 6s. 7d. per lamp per annum.

With type C of engine and boiler the cost of maintenance will be as follows:—

Repairs on £5,000 buildings, at 5 per cent.	£250	per annum.
,, £10,600 electric apparatus, at 10 per cent.	1,060	,,
,, £16,700 engines and boilers, at 10 per cent.	1,670	,,
,, £8,880 distributing plant, at 5 per cent.	444	,,
	£3,424	

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i.e., ·219 pence per I.H.-P. per hour, which is at the rate of ·028 pence per lamp per hour, or 7s. per lamp per annum.

III.—MANAGEMENT:—

For the cost of management the sum of £500 may safely be assumed to cover all outlays under this head upon an installation of 10,000 incandescence lamps.

£500 per annum = ·32 pence per I.H.-P. per hour, *i.e.*, ·004 pence per lamp per hour, or 1s. per lamp per annum.

INTEREST ON CAPITAL.

Employing type A of engine and boiler, we have:—

Interest on £44,726, at 5 per cent., = £2,236 per annum, or ·143 pence per I.H.-P. per hour, *i.e.*, ·018 pence per lamp per hour, or 4s. 6d. per lamp per annum.

With type B of engine and boiler the capital being larger the interest is proportionately increased.

Interest on £49,511 at 5 per cent. = £2,475 per annum, which is = ·158 pence per I.H.-P. per hour, or = ·02 pence per lamp per hour, or 5s. per lamp per annum.

If type C be employed, the annual cost of interest on capital per lamp is about the same thus:—

Interest on £50,798 at 5 per cent. = £2,540 per annum, or ·162 pence per I.H.-P. per hour, *i.e.*, ·02 pence per lamp per hour, or 5s. per lamp per annum.

Summarising the above figures in a tabular form, we have the following table of the cost of working the installation, with the three types A. B. and C. respectively of engine and boiler:—

Working Cost.	Cost per lamp, using compound non-condensing engines and Lancashire boilers, consuming 2·7lb. of coal (at 7s.) per I.H.-P. per hour.		Cost per lamp, using compound condensing engines and Lancashire boilers, consuming 2·3lb. of coal (at 7s.) per I.H.-P. per hour.		Cost per lamp, using compound condensing engines and "locomotive" boilers, consuming 2lb. of coal (at 9s.) per I.H.-P. per hour.	
	Per hour.	Per ann. of 3,000h.	Per hour.	Per ann. of 3,000h.	Per hour.	Per ann. of 3,000h.
	pence.	s. d.	pence.	s. d.	pence.	s. d.
Production	·022	5 6½	·02	5 0	·022	5 6
Maintenance	·023	5 9	·026	6 6	·028	7 0
Management	·004	1 0	·004	1 0	·004	1 0
Interest on Capital at 5 per cent	·018	4 6	·02	5 0	·02	5 0
Total cost.....	·067	16 9½	·07	17 6	·074	18 6

The above figures indicate that the saving of coal effected by the adoption of condensing engines is not so great as the increase of working cost, due to repairs and interest on capital for an installation of this size, in a town like Sheffield, where coal can be had at an exceptionably cheap rate and, when it is considered, moreover, that, added to the above working cost, there must be a considerable item for the supply of condensing water, I do not feel justified in recommending the adoption in the present case of condensing engines, although in my opinion for very large installations, such as will be required when electric lighting for public and private purposes becomes general, there will be a most decided advantage in the employment of the most economical working power, even in places where coal is cheap.

It must be noted that the capital expenditure and working cost mentioned in this report are calculated on the assumption that the whole number of ten thousand lights are in action during the whole year's working of three thousand hours; or, in other words, that the producing plant has an annual demand upon it of thirty million lamp-hours; but this result can hardly by any possibility be attained in practice, and I should consider that the average would not exceed half that amount, for the number of lights in operation at any one moment depends upon a number of individual and local circumstances. Thus in a district (such as that proposed to be lighted in Sheffield) consisting mainly of shops and houses of business there will be great differences in the period during which the lights of different establishments are in operation. For example:—Some shops shutting up at 6 o'clock would turn out their lights at 6:15, many close at 8, and a large number at 10, while some remain open still longer. Banks, on the other hand, would shut off at 5 or half-past, and thus during the winter, while some might keep their lights running as long as nine hours others would be cut off after only one hour's working. Again, on Sunday, that is for a period equal to one-seventh of the year, or nearly 430 working hours, very few, if any, lights would be used in shops or houses of business, and the number would be reduced to what was required for domestic purposes. On the other hand, on dark, foggy days, and in places poorly lighted by daylight, the lights might be required during the whole of or for a large portion of the day, and in some establishments they might be kept going all night. All these considerations show that the demand upon the producing plant at any one hour would be different in different places, and also that it would be very variable from hour to hour.

Against, however, such exceptional demands must be set the fact that during the summer months the lights of some of the largest establishments would not be in use at all, while in all the duration of burning would be reduced as the days increased, and thus the annual working cost would be proportionately reduced.

Again, there must be expected to be some variation in the number of lights in operation in any one establishment. For example, in shops in which work is carried on after the establishment has been closed to the public, the lamps illuminating the windows and shop front would be shut off earlier than in the rest of the building; but it will be readily understood that the larger the installation driven from one connected system of conductors, whether deriving their electricity from one or more than one producing station, the more uniform will be the demand and the closer will it approximate to an average constant. Taking all these considerations together, I am inclined to think that, except on rare occasions affecting the whole community alike, such, for example, as a general illumination on an occasion of public rejoicing, there would never occur an instance of all the lamps being in action at the same time for many hours together.

I have in the earlier part of this report recommended the employment of electric lighting by incandescence for the *private* lighting of the district, for the reasons already stated. It must, however, be a matter for the subsequent consideration of the Corporation whether it will be advisable on their part or not to recommend to consumers the employment of any one system of incandescence lighting or special form of lamp. Of these there are four principal kinds, named respectively after their several inventors—the Swan, the Edison, the Lane-Fox, and the Maxim—each possessing distinguishing characteristics of its own.

It is, however, contrary to the provisions of the Electric Lighting Act of 1882, as it exists at the present date, for the Corporation, as undertakers, to specify or insist upon the consumers employing any particular form of lamp. On the other hand, it is highly desirable in the interests of the consumers, as well as for the success of the undertaking, that no apparatus be employed by consumers that shall either through failure or otherwise bring discredit on the undertaking.

To meet this, I would propose that the Corporation without in any way insisting on the employment of any special lamp, should encourage the adoption of a lamp best suited to the installation, either by offering certain advantages in the supply, or putting up of such lamps, or by the entering into of an arrangement with certain firms, local or otherwise, for the supply and fitting of those lamps which, in the opinion of the Corporation, are most suitable; such firms agreeing to supply and fit lamps at a price advantageous to the consumer in consideration for the recommendation and general guarantee of the corporation. It would in all cases be necessary to make it a condition of supply that no lamp or appliance of any sort be employed by a consumer that has not been previously approved of by the corporation or their scientific advisers. A provision of this sort, made solely in the interests of the general body of consumer, could not be, in the smallest degree, contrary to the spirit of the Electric Lighting Act, or of the rules of the Board of Trade, and would, I believe, meet with general approval. It is, moreover, a condition applicable and necessary alike to all systems of lighting in which a community of consumers is supplied from a common centre, and, therefore, is as necessary for gas lighting as for electric illumination.

As bearing upon the capital required for installation, as well as the cost of working the same, I may point out that the estimate hereinbefore set forth is based upon manufacturers' prices. It is probable, however, that with the keen competition which must accompany the extended adoption of electric lighting, such prices may be reduced, or considerable discounts allowed, thus reducing the capital required.

CONRAD W. COOKE.

5, Westminster-chambers, London, S.W.,
November, 1882.

TO OUR READERS.—We are compelled to leave over till our next issue an article on "Insulators," by Mr. A. R. Bennett.

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CANTOR LECTURES.*

Dynamo-Electric Machinery.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture III.—The Dynamo as a Motor.

(CONTINUED FROM PAGE 275.)

In my first lecture, I laid down the definition that dynamo-electric machinery meant "machinery for converting the energy of mechanical motion into the energy of electric currents, or *vice versâ*." In the two lectures which I have already had the honour of delivering, I have treated the dynamo solely in its functions as a generator of electric currents. In this third lecture I come to the converse function of the dynamo, namely, that of converting the energy of electric currents into the energy of mechanical motion.

An electric-motor, or, as it was formerly called, an electro-magnetic engine, is one which does mechanical work at the expense of electric energy; and this is true, no matter whether the magnets which form the fixed part of the machine be permanent magnets of steel or electro-magnets. Any one, in fact, of the four kinds of dynamos, can be used conversely as a motor, though, as we shall see, some more appropriately than others. But whether their field-magnets be of permanently magnetised steel or of temporarily magnetised iron, all these motors are electro-magnetic in principle; that is to say, there is some part either fixed or moving which is an electro-magnet, and which as such attracts and is attracted magnetically.

Every one knows that a magnet will attract the opposite pole of another magnet, and will pull it round. We know also that every magnet placed in a magnetic field tends to turn round and set itself along the lines of force. Let me, as a first illustration of this class of actions, exhibit to you the nature of the forces at work in the magnetic field. In the figure which I now throw upon the screen (an electrification of the action of a magnetic field on a magnetic needle), we have, in the figure which I now throw upon the screen (an illustration of the action of a magnetic field on a magnetic needle), we have, in the first place, a simple magnetic field produced between the poles of two strong magnets, one on the right, the other on the left. Between the two, confined forcibly at right-angles to the lines of force, I hold a small magnetic needle. Iron filings sprinkled in the field reveal the actions at work in a most instructive way. Faraday, who first taught us the significance of these mysterious lines of force, has told us that we may reason about them as if they tended to contract or grow shorter. Now, a simple inspection of the illustration on the screen will show that the shortening of the lines of force must have the effect of rotating the magnetic needle upon its centre, through an angle of 90deg., for the lines stream away on the right hand above, and on the left hand below, in a most suggestive fashion. It is not, therefore, difficult to understand that very soon after the invention of the electro-magnet, which gave us for the first time a magnet whose power was under control, a number of ingenious persons perceived that it would be possible to construct an electro-magnet engine in which an electro-magnet, placed in a magnetic field, should be pulled round; and, further, that the rotation should be kept up continuously, by reversing the current at an appropriate moment. As a matter of fact, a mere coil of wire, carrying a current, is acted upon when placed in the magnetic field, and is pulled round as a magnet is (an illustration of this was given). The magnetic field is, as before, produced between the ends of two large magnets. The two round spots are two holes drilled in the sheet of glass, where the wire which carried the current came up through the glass and descended again. You will notice how the lines of iron filings, which would, if there were no current, run simply across from left to right, are bent out of their course. If these lines could shorten themselves, they must, of necessity, twist the loop of wire round, and cause it to set at right angles to its present position.

On this very principle was constructed the earliest electric-motor of Ritchie, so well known in many forms as a stock piece of electric apparatus, but little better in reality than a toy.

A great step in advance was made by Jacobi, who, in 1838, constructed the multi-polar machine. This motor, which Jacobi designed for his electric boat, had two strong wooden frames, in each of which a dozen electro-magnets were fixed, their poles being set alternately. Between them, upon a wooden disc, were placed another set of electro-magnets, which, by the alternate attraction and repulsion of the fixed poles, were kept in rotation, the current which traversed the rotating magnets being regularly reversed at the moment of passing the poles of the fixed magnets, by means of a commutator consisting, according to Jacobi's directions, of four brass-toothed wheels, having pieces of ivory or wood let in between the teeth for insulation. Jacobi's motor is, in fact, a very advanced type of dynamo, and differs very little in point of design from one of Wilde's most successful forms.*

A still earlier rotating apparatus, and, like Ritchie's motor, a mere toy, was Barlow's wheel, described in 1823. This instrument, interesting as being the forerunner of Faraday's disc dynamo, is the representative of an important class of machines, namely, those which have a sliding contact merely, and need no commutator.

A fourth class of motors may be named, wherein the moving part, instead of rotating upon an axis, is caused to oscillate backwards and forwards. Professor Henry, to whom we owe so much in the early history of electro-magnetism, constructed, in 1831, a motor with an oscillating beam, alternately drawn backwards and forwards by the intermittent action of an electro-magnet. Dal Negro's motor of 1833 was of this class; in it a steel rod was caused to oscillate between the poles of an electro-magnet, and caused a crank, to which it was geared, to rotate in consequence. A distinct improvement in this type of machine was introduced by Page, who employed hollow coils or bobbins as electro-magnets, which, by their alternate action, sucked down iron cores into the coils, and caused them to oscilate to and fro. Motors of this kind form an admirable illustration of one of the laws of electro-magnetics, first formulated by Gauss, but developed later by Maxwell, to the effect that a circuit acts on a magnetic pole in such a way as to make the number of magnetic lines of force that pass through the circuit a maximum. Once more I have recourse to iron filings to illustrate this abstract proposition of electric geometry.

In the illustration before you the north pole of a bar magnet is placed opposite a circuit or loop of wire traversed by a current, and which comes up through the glass at the lower hole, and descends at the upper hole. The tendency to draw as many as possible of the magnet's lines of force into the embrace of the circuit is unmistakable. If now we reverse the current, what do we find? that the magnet's lines of force, instead of being drawn in, are pushed out. In fact, in one case, the pole is attracted, in the other repelled.

Page's suggestion was further developed by Bourbouze, who constructed a curious motor, which looks uncommonly like an old type of steam engine. We have here a beam, crank, fly-wheel, connecting-rod, and even an excentric valve-gear and a slide valve. But, for cylinders, we have four hollow electro-magnets; for pistons, we have iron cores, that are alternately sucked in and repelled out; and, for slide valve, we have a commutator, which, by dragging a pair of platinum-tipped springs over a flat surface made of three pieces of brass separated by two insulating stripe of ivory, reverses at every stroke the direction of the currents in the coils of the electro-magnets. It is really a very ingenious machine, but, in point of efficiency, far behind many other electric motors. Unfortunately, it does not do to design dynamo-electric machinery on the same lines as steam-engines.

Yet a fifth class of electric motors owes its existence to Froment, who, fixing a series of parallel iron bars upon the periphery of a drum, caused them to be attracted, one after the other, by an electro-magnet or electro-magnets, and thus procured a continuous rotation.

Lastly, of the various types of motor we may enumerate a class in which the rotating portion is enclosed in an excentric frame of iron, so that as it rotates, it gradually approaches nearer. Little motors, working on this principle of "oblique approach," were invented by Wheatstone, and have long been used for spinning Geissler tubes, and other light experimental work. More recently, Trouvé and Wiesendanger have sought to embody this principle in motors of more ambitious proportions, but without securing any great advantage.

It would be impossible, within the limits of a lecture, to deal with a tithe of all the various stages of discovery and invention, and if it were my intention to deal with the subject from the historical point of view, I might speak of many interesting and curious machines that have from time to time been tried. I might tell you how Page, after inventing his machine in 1834, succeeded, in 1852, in constructing a motor of such a size that he was able to drive a circular saw and lathe by it. I might describe the electric-motor of Davidson, which, in 1842, enabled him to propel a carriage, at the speed of four miles an hour, between Edinburgh and Glasgow. I might describe the engine, built in 1849, by Soren Hjörth, at Liverpool, which was of ten horse-power.

All these early attempts, however, came to nothing, for two reasons. At that time there was no economical method of generating electric currents known. At that time, moreover, the

* Reprinted from the *Journal of the Society of Arts*.

* Wilde's is, however, designed as a generator. Jacobi's, on the contrary, was designed as a motor; though, of course, it would generate currents if driven round by mechanical power.

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great physical law of the conservation of energy was not recognised, and its all-important bearings upon the theory of electric machinery were not available.

While voltaic batteries were the only available sources of electric currents, economical working of electric motors was hopeless. For a voltaic battery, wherein electric currents are generated by dissolving zinc in sulphuric acid, is a very expensive source of power. To say nothing of the cost of the acid, the zinc—the very fuel of the battery—costs more than twenty times as much as coal, and is a far worse fuel; for whilst an ounce of zinc will evolve heat to an amount equivalent to 113,000 foot-pounds of work, an ounce of coal will furnish the equivalent of 695,000 foot-pounds.

The fact, however, which seemed most discouraging, and which, if rightly interpreted in accordance with the law of conservation of energy, would have been found to be (on the contrary) a most encouraging fact, was the following:—If a galvanometer was placed in the circuit with the electric motor and the battery, it was found that when the motor was running it was impossible to force so strong a current through the wires as that which flowed when the motor was standing still. Now, there are only two causes that can stop such a current flowing in a circuit; there must be either an obstructive resistance or else a counter electromotive force. At first, the common idea was that, when the motor was spinning round, it offered a greater resistance to the passage of the electric current than when it stood still. The genius of Jacobi enabled him, however, to discern that the observed diminution of current was really due to the fact that the motor, by the act of spinning round, began to work as a dynamo on its own account, and tended to set up a current in the circuit in the opposite direction to that which was driving it. The faster it rotated the greater was the counter-electromotive force (or "electromotive force of reaction") which was developed. In fact, the theory of the conservation of energy requires that such a reaction should exist.

We know that, in the converse case, when we are employing mechanical power to generate currents by rotating a dynamo, directly we begin to generate currents—that is to say, directly we begin to do electric *work*—it immediately becomes much harder work to turn the dynamo than is the case when no electric work is being done. In other words, there is an opposing reaction to the mechanical force which we apply in order to do electric work. An opposing reaction to a mechanical force may be termed a "counter-force." When, on the other hand, we apply (by means of a voltaic battery, for example) an electromotive force to do mechanical work we find that here, again, there is an opposing reaction, and an opposing reaction to an electromotive force is a "counter-electromotive force."

The experiment of showing the existence of this counter electromotive force is a very easy one. All one requires is a little motor, a few cells of battery, and a galvanometer. The galvanometer I shall use to-night is one which I brought out some years ago, and which has proved itself very convenient for lecture work, because it can be put into any ordinary lantern and projected on the screen. I have here, as a battery, four small accumulators of the Faure-Sellon-Volckmar type, and I have connected them with a little motor, also of my own design, the current being arranged so as to run through the galvanometer. I hold the spindle of the motor fast, so that it cannot rotate, and you see that the pointer of the galvanometer indicates 44deg. I now release the motor; it begins to rotate, and as its speed increases, you observe the needle descend the scale to 23deg., and eventually to about 15deg. If I load the motor and cause it to slacken speed, the needle at once returns.

The existence of this counter-electromotive force is of the utmost importance, in considering the action of the dynamo as a motor, because upon the existence and magnitude of this counter-electromotive force, depends the degree to which any given motor enables us to utilise electric energy that is supplied to it in the form of an electric current. In discussing the dynamo as a generator, I pointed out many considerations, the observance of which would tend to improve the efficiency of such generators. It is needless to say that many of these considerations, such as the avoidance of useless resistances, unnecessary iron masses in cores, and the like, will also apply to motors. The freer a motor is from such objections the more efficient will it be, but the efficiency of a motor in utilising the energy of a current depends not only on its efficiency in itself but on another consideration, namely, the relation between the electromotive force which it itself generates when rotating and the electromotive force—or, as some people call it, the electric pressure—at which the current is supplied to it. A motor which itself in running generates only a *low* electromotive force cannot, however well designed, be an *efficient* or economical motor when supplied with currents at a *high* electromotive force. A good low-pressure steam engine does not become more "efficient" by being supplied with high-pressure steam; nor can a high-pressure steam engine, however well constructed, attain a high efficiency when worked with steam at low pressures. Analogous considerations apply to dynamos used as motors. They must be supplied with currents at electromotive forces adapted to them. Even a perfect motor—one without friction or resistance of any kind—cannot give an "efficient" or economical result, if the law of efficiency is not observed in the conditions under which the electric current is supplied to it.

Now it can be shown, mathematically, that the efficiency with which a perfect motor utilises the electric energy of the current depends upon the ratio between this counter-electromotive force and the electromotive force of the current that is supplied by the battery. No motor ever succeeds in turning into useful work the whole of the currents that feed it, for it is impossible to construct machines without resistance, and whenever resistance is offered to a current part of the energy of the current is wasted in heating the resisting wire. Let the symbol W stand for the whole electric energy of a current, and let w stand for that part of the energy which the motor takes up as useful work from the circuit.* All the rest of the energy of the current, or $W-w$, will be wasted in useless heating of the resistances.

But, if we want to work our motor under the conditions of greatest economy, it is clear that we must have as little heat-waste as possible; or, in symbols, w must be as nearly as possible equal to W. It can be shown, mathematically, that the ratio between the useful energy thus appropriated, and the total energy spent, is equal to the ratio between the counter-electromotive force of the motor, and the whole electromotive force of the battery that feeds the motor. The proof will be given later. Let us call this whole electromotive force with which the battery feeds the motor E, and let us call the counter-electromotive force e. Then the rule is—

$$w : W = e : E,$$

or, if we express the efficiency as a fraction,

$$\frac{w}{W} = \frac{e}{E}.$$

But we may go one stage further. If the resistances of the circuit are constant, the current c, observed when the motor is running, will be less than C, the current while the motor was standing still. But, from Ohm's law, we know that

$$c = \frac{E - e}{R}.$$

Hence $\frac{C - c}{C} = \frac{e}{E} = \frac{w}{W}$. From which it appears that we can calculate the efficiency at which the motor is working, by observing the ratio between the fall in the strength of the current and the original strength. Now, this mathematical law of efficiency has been known for twenty years,† but has been strangely misapprehended. Another law, discovered by Jacobi, not a law of efficiency at all, but a law of maximum work in a given time, has usually been given instead.

(TO BE CONTINUED.)

THE TELEPHONE CASE.

JUDGMENT.

The Master of the Rolls, in giving judgment on Tuesday in the case of the United Telephone Company *v.* Harrison, Cox-Walker and Co., said: This is an appeal from the decision of Mr. Justice Fry, who found in favour of the plaintiffs with reference to the infringement of a portion of a patent. The portion referred to is the receiver in Bell's patent. Before proceeding further with my judgment, I wish to say that in my opinion the case has been elaborately and remarkably argued on both sides. If I have any complaint at all—which, perhaps, I should not make in a case of this kind, where I have derived so much assistance from the Bar on the subject—it is that, perhaps, the arguments might have been compressed. Subject to that observation, I have only

* This symbol w must be clearly understood to refer to the value of the work taken up by the motor, as measured electrically. The whole of this work will not appear as useful mechanical effect, however, for part will be lost by mechanical friction, and part also in the wasteful production of eddy-currents in the moving parts of the motor. What proportion of w appears as useful mechanical work depends on the efficiency of the motor *per se*, which we are not here considering. In all that follows immediate ly we shall suppose such causes of loss not to exist; or the motor will be considered as a perfect motor.

† See Verdet's "Théorie Mécanique de la Chaleur," where, however, Verdet makes the very mistake so often made, of supposing that the greatest possible efficiency of a motor, working with a given electromotive force, is 50 per cent., or its efficiency when working at the maximum rate.

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to thank the Bar for the great advantage I have derived from their arguments and from the information afforded. The patent is admittedly one of great merit. It is one of the most important and remarkable inventions of the century, and if it fails in any part it will fail from being made too wide in some of the descriptions, and not being sufficiently distinct. I have said on many occasions, and I say again, when you take out a patent of great and acknowledged merit, it is the duty of the judge, so far as he can consistently with the rules and construction of the specification, to read that patent so as to support and not to defeat it. And that is what I understand of all that has been said about the "benevolence" construction of the statute. The objections raised to the patent are these: —The first objection raised on the part of the appellant was that there was no infringement at all. Now, that depends upon the mode in which you construe the specification. I do not understand that that point was made before the Court below in that wide form, but I consider it to be material. There are two portions which are alleged to have been infringed. One is the permanent magnet, which is called Hickley's, the other the electro-magnet, which is known as the Cox-Walker. As regards the Hickley, I think it is so clear it is not worth discussing; but the suggestion made is this—it was not for an infringement, because the defendants bought it now and again, and were not the persons who sold it regularly, or manufactured it. There was put in evidence before us the defendants' own prospectus, or circular, and it was obvious that they represented to the public they were the manufacturers of the Hickley as well as the Cox-Walker, and they sold it as their own production. I think, therefore, as far as that goes they had no ground whatever for complaint, and the infringement, so far as that is concerned, is plain. As regards the last case—that is, of infringement—that is dependent, no doubt, upon the reading of the specification. I am not going to say, and it is not my opinion, that this is anything but a difficult specification—difficult to construe even now in the light of the further knowledge we possess, and certainly it must have been extremely difficult at the time it was published, and when we knew little about that subject. And, as far as I am concerned, notwithstanding the observations of Mr. Webster, I always felt comfortable as judge of first sittings in knowing there was an appeal from my decisions. I gave them with more confidence when I knew there would be no appeal. This is a case of very great importance, and may be carried further, and if it is carried further I shall be glad of it. Now, what does this specification mean? Does it fairly describe the patent? The description is contained in a very few lines. Before going to that, I may say a word or two about another anticipation. There was an anticipation under Reis's patent. I have looked at it, and I have nothing to add to that judgment. With regard to the invention it is described at p. 18. That has been objected to as going beyond the law. I do not think it does. As I read the variation, it does not appear to me to do more than to say that a plate of thin steel might be used, and I do not see, for myself, that it adds or takes away anything that is material. It seems to me that even if it did, as the law now stands, it does not destroy the effect or strike out the variation. I really think, when you look at it fairly, it does not add anything, and it may be discarded for every substantial purpose from the construction of the patent. Now the first question to consider is what does that mean? It evidently means that the receiver and the transmitter are the same, because it obtains similar motion in a similar steel plate. Then, again, as to the vibrations of the plate in front of the magnet. It shows not only that the plate is in front of the magnet, but that it is attached in front. Then the drawing points this out. It shows that it is attached by two buttons or screws. Now, does it show another mode of attachment? I cannot imagine anybody, having the right, who would not attach it by at least two screws. I have no doubt that any decent workman would have at least put two more. I do not know that it would make much difference. I think he would put two screws at each side at least. I think all that is told us by the specification. It is told us there is this thin plate or disc in front of the magnet, close to the magnet, separate from the magnet, fixed or attached, and in such a way as to keep the whole circumference fixed. That is the thing which is described, and I think sufficiently. The question is, do the defendants infringe? There is no doubt what they used is nipped or capped down by a top screw, similar and for the same purpose. It is only trifling with words to say that is not substantially the same thing as what the plaintiff has described. Therefore, on this question of infringement, my opinion is quite as adverse to the defendants as regards the Cox-Walker as it is with regard to the Hickley. Now we come to a very different and difficult point. Assuming it is an infringement, is the plaintiff's patent bad for want of novelty? Has it been previously published? The singularity of the case is this—if it is a publication, is it a publication of the patentee's own? If a prior invention is not substantiated, it is his. The history of the case is simple. The patentee himself declared I am an inventor, not of the present invention, as it turns out, but a similar invention, and not so perfect—it was in an imperfect or inchoate state. But still he published it to glorify it, and gave the instrument to Sir William Thomson, who was going to the meeting of the British Association at Glasgow for the purpose of publishing it to the world. Now, Sir William Thomson is a great electrician, but I think he was not quite candid with the British Association, because before the meeting he tried to work the machine, and says he could not work it. Something had gone wrong. What it was I will say no more about. He made a speech to the British Association in which he did not tell them he could not work it. He told them, no doubt, what was perfectly true, but at the same time he said he had seen something similar to that he held in his hand at Philadelphia, producing something of articulate sounds, but he did not tell them he had tried to work it himself. He trumpeted forth as a great invention one of those marvellous inventions of a new something which would glorify Mr. Graham Bell to eternity, but he never told them what was the position of matters. When we come to see what had happened this occurred. Somebody or other had told a mechanic who made the instrument for Sir William Thomson to put a screw on the top of the case which contained the magnet, and to screw down the disc. That this had been done purposely is obvious, for the plate juts out from the case, and there is a hole made in it, and a screw put in it. Somehow or other by the shaking of Sir William Thomson's portmanteau, the case containing the magnet got crumpled or creased, and the result was instead of lying flat on the top of the disc, it was slightly raised so as to tilt, and not to touch the case containing the magnet, except at the point where it was fastened with the screw. When it was shown by Sir Wm. Thomson to the British Association, with the suppression of the fact that it would not work, and with a speech which would have led us to expect it would produce marvellous results, everybody could see, who looked at it with attention, that it was tilted. Nobody knew how to work it. The state of knowledge in this country at that time was not so advanced as it is now, and nobody could make anything of it. It was there for several days in the museum or place attached, and nobody could make anything of it—nobody knew how it would work or how it was worked. That leads me to this point—whether the publication shown or not shown was the publication of the "Glasgow," which is something with a top or disc, or something which was permanently and purposely altered. It is impossible to answer that question without you know the minds of the people, and if they had known what is known now, nobody would have understood that the current was strong enough to draw it down. I am satisfied at that time nobody knew those things—they were not acquainted with the mode in which it was worked. Sir William Thomson states he thought at the time that the crease or crumple was done on purpose, and was part of the concern. He does not put it in those words—he speaks of it as not being accidental, and as being produced by a regular cause. The material point to my mind is this: Are you satisfied that there was no ordinary intelligent workman who would have made that thing work? We have this criterion. We have a description in a newspaper, we have a drawing which shows it, and though we have no drawing which shows what it was at first I am satisfied it was different when it was shown at Glasgow. The next question is this: What was the effect of the thing? I agree if you publish an instrument you may publish so as to effect a subsequent patent if your description is as good as that required in the specification, and if you have a new instrument and state its use it is quite sufficient. I will give an illustration to show what I mean. Suppose flutes were unknown, and suppose a man invented this beautiful wind instrument, which, when blown upon, gives out delightful and harmonious sound. It is described as a wind instrument, but if there was nothing to tell what it was, for nobody could use it unless he knew how to move the lips—he must be taught to blow the lips. He would have to be taught whether he is to blow alongside or at the top. The specification is not the less good on that account. It would not be sufficient to say at the date of that specification nobody knew how to blow the flute. Though nobody knew how to make a receiving instrument, yet if we are told this is a telephonic receiver that will give articulate sound, and that to say it is such is a publication of the receiver, it would none the less be a publication because nobody knew how to receive it. There was some form of transmitters at that date that would give articulate sound. I think one ought to hold what took place at Glasgow was a publication of what I will call the Glasgow uncorrected. Is the invention afterwards patented the same receiver, or is it a different receiver, so different as to be capable of being sustained? We must consider what is claimed as the subsidiary part of a great invention to support that claim. In considering the merit of an invention you must consider it as a whole, and you do not require the same amount of merit to support the subsidiary claim to a subsidiary part of an instrument which you do to support the entire invention. If we find that this thing which is the subject matter of this subsidiary case is not the same thing, and that it possesses some advantages —and when I say that I mean real advantages—then it is sufficient. What do we find? In the first place, that there is a difference from the thing shown at Glasgow, whether corrected or uncorrected in several particulars which have been pointed out. In the first place the disc is fastened by a different mode of attachment—in the one case by a screw and in the other by a piece of wood. It appears to me the different mode of fastening or adjustment is material, and the evidence shows that when it was fastened with a screw it got crumpled or creased or out of order, whereas when fastened the other way there was no such probability, and that is an advantage which speaks for itself. I am satisfied from the experiments when you have a very high resistance in the magnet that the mode adopted by the patentee gives better results than the Glasgow machine. I do not say that with a very high power with the Hunning it might not be so, but I do find a distinction with a low power and a greater. I thought one was better than the other. I thought the difference was rather in favour of Bell's instrument over the Glasgow instrument. There is another point. Bell's instrument can certainly be used as transmitter or receiver. As far as I can see, I am unable to dissent from the conclusion of the judge below that it can be so used. If it can be so used, it was the duty of the appellants to show us. There are other points of difference, but they are very slight. The position of the magnet is different. Summing up the whole it appears to me that there is a difference of form, a difference of construction between the receiver patented by Bell and a difference in its use, and, to a certain extent, as between that shown at Glasgow and that which is now described as an invention; and, considering that which you require when you have an invention of great merit and very little to support the subsidiary claim, I think we should not be doing our duty in upsetting this case on such grounds as these. I now come to the last point, which, like all the points in the case, is a serious and difficult one, and that is as to the operation of the disclaimer upon the original claim. Although, perhaps, not very happily drawn, it appears to be fairly confined to the original use claimed, and does not operate to vitiate the patent. The case is one of very great difficulty, and I am not able to say, reviewing the whole of the case, that I am able to arrive at a different conclusion to that which was arrived at by the judge below.

On Wednesday Lords Justices Lindley and Bowen concurred. We hope to give the text of their judgments in our next issue. We may state here, that the evidence given before Mr. Justice Fry in the original case, tried in May last, together with his judgment and illustrations of the various instruments referred to during the case, appeared in Vol. IX. of *The Electrician*, pp. 31, 36, 54, 80, and 115.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of January, 1883, were £1,689, against £2,055 for the corresponding period of last year.

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THE BRITISH INSULITE COMPANY (LIMITED).

The second ordinary general meeting of the shareholders of this Company was held at the Guildhall Tavern on the 5th inst., under the presidency of the Right Hon. E. P. Bouverie.

The SECRETARY having read the notice convening the meeting,

The CHAIRMAN in the course of his observations in moving the adoption of the report and accounts said: In accordance with the provision in the Articles of Association, this meeting has been called for the purpose of submitting the state of the accounts and for other ordinary business of of the Company. I shall deem it my duty to occupy your time for a few minutes in explaining what the position of the Company is. In the first place I should say you are aware it has been in existence for only about eight months. The latter part of May was the time when the Company was formed, and since then we have had to set to work at the Board to get the operations of the Company set in motion. The accounts really set forth the position of the Company, but there is an ambiguity in one item in those accounts on the credit side which I shall be glad to explain to you. Perhaps it would be better that I go over the items in the accounts, which will help to make the remarks clearer which I shall have subsequently to make. First of all there is, on the debtor side of the balance-sheet, an item debited to sundry creditors. The moiety of that is for directors' fees, which I should mention have been unpaid. We thought as the Company was inchoate (not at work, at any rate) it was well not to draw the fees. Thus more than half of the item of sundry creditors on the debit side of the balance-sheet represents our fees. On the credit side you see the cash payments and the legal expenses set forth. Then come five items beginning with leasehold property and ending by cash at bankers, all of which are assets of the Company. The leasehold property has been entered in the accounts at cost. We have established our works. I should mention that we were enabled, after some difficulty, to find what I think is a perfectly appropriate site, and that we bought it at a very low figure, with some machinery which was thrown in. The Board has had the leasehold property valued, and, apart from the machinery which was included in the £1,925 that we gave, a very competent surveyor who is not exaggerated in his ideas of the value of property, but who has great knowledge and experience of leasehold property, puts the building and site—the lease alone—as worth at least £2,000, and the machinery which we got thrown in we have had valued to us as being worth about £700. Therefore we had a good bargain there. The plant and machinery have been purchased since. The item does not include the whole of the plant we have been acquiring. The office furniture speaks for itself. The item stock on hand has been misunderstood. It has been supposed to mean manufactured stuff which we could not sell. That impression, however, is wrong. It is materials for manufacture that we have on hand, some of which is very valuable, which we thought well to lay in a good stock of before we commenced, and which I understand, if sold in the market now, would be worth more than we gave for it. That, therefore, is fully equal to cash. The item of cash at bankers speaks for itself. Altogether I make out, without giving the valuation of the leasehold property at a higher rate than we put down, we have assets of over £7,000. Then there is a charge for preliminary expenses, which is always a feature in connection with the establishment of companies, and the liquidation of which with us in our future arrangements will have to be spread over a short series of years. The main part of that—more than half—has been incurred in advertising. Of the last item—administration expenses—half has been actually paid, and I could, if necessary, give you the details of that. I think what I have said, therefore, will enable you to see that we are in most respects ready to begin operations, but unfortunately up to the present period we have not been able actually to commence work. We have got buildings and materials, and we hope to get the machinery. The main part of the profit which is expected to be derived, I may say the whole, from the manufacture of this material, will be got from making it in a large way, and in a cheap and economical manner. The great merit of this patent invention to which we have the right is that it produces a material which is in large request, which is a necessity I may say nowadays of electrical existence, and which can be produced by this process cheaper and better than anything else known in nature. The result will be, if we are right in our anticipation, that there must be a very large demand for a variety of electrical purposes for the stuff we shall be able to produce, and of course the cheaper the way in which we can produce it, the larger the profits of the manufacture. There have been several minor improvements made in the method of manufacture since this material was first invented, and the method of treatment actually hit upon. It has been ascertained that instead of putting the stuff in blocks, and then cutting to the pattern required, it admits on given conditions of being moulded into any shape which admits of moulding. To do this on a large scale and cheaply involves the erection of certain machinery. Our first difficulty was to get a place to carry on our works. There were some peculiar conditions attached to that requisition, one being that it should be in the way and out of the way, where it would be readily accessible, as the materials we have to deal with are for the most part materials of large bulk, and, therefore, that it should be near a railway station or the river, and another that it should not be near any large population, as, in making it, there are some odours which are supposed to be offensive. We know by the experience of the small experimental works established at first in Westminster that there was a complaint of a nuisance on the part of the authorities, and legal steps were threatened. We, therefore, had to provide for this, and after making one or two efforts in another direction by great good fortune, and I think partly through the diligence of our secretary, we succeeded in finding a place which is eminently fitted to all our requirements. It is down at Charlton, within fifty yards of the railway station. It has access to the river and also to the railway, and it is out of the way. There is no population about it. It combines every possible thing we could require for our purposes, and it had the advantage of being very cheap. We have a lease of it for about thirty years—I believe it is thirty-four years—at a moderate rent. Then having got the site (and this took us some time, we did not get the conveyance till September) we had to get the machinery, and it was necessary that the machinery should be adapted to the place. The machinery had to be devised (and that took some time), and it then had to be designed by competent people. Then it had to be given out to be executed. We found that the machinery makers were so full of work that they were very unwilling to have it promised for a certain time, and the result has been practically that we have only been able to get our machinery delivered piecemeal, and the last thing which hung fire was that which we thought we might have got in the first instance, viz., the engine, which was ordered of a maker who was a very large maker, and who promised it in about six or seven weeks; but he has taken over three months to execute the order, and only to-day have we heard of the delivery of the engine. I believe that the difficulty of getting such orders executed is a matter of everyday experience, and if we were to endeavour to get a penal clause inserted in the agreement, the manufacturers would not take the order. As regards this engine, it was the last thing we required, everything else being ready. As to the final completion of the order, our legal advisers had to write a letter to the maker. At last, however, we hear to-day that the engine has been delivered, and I understand now that in the course of two or three weeks we hope to have everything put together, and to set the machinery going, and produce what we have to produce. What we have got to do now is to get orders for our stuff. Of course, in a new invention like this, the expectation that this stuff will be required, and that there will be a large demand for it, is more or less a speculation—that is to say, it is in the womb of the future to decide whether our expectations that there will be a great demand for it will be realised or not. I can only say as to that, that I judge to a certain extent on general principles, and partly endeavour to form my own opinion as to the state of the case. When you have a monopoly of something that people do not care much about, or which is a matter of fashion, it is quite possible that the demand may cease or the fashion change; then you may be left with no real demand for that which you produce. But when you produce what I may call a necessity of existence of any kind, and have a practical monopoly of it, and are able to produce it better and cheaper than any one else, then those requiring it must come to you, and there is a fair chance of making a very large profit. That is exactly the general principle in relation to which we stand. We believe we have by our patent the right of making something which electricians for a variety of purposes must have. For batteries, for the minor appliances of telephony, of electricity, and for insulators of all kinds, insulating material is absolutely necessary. One of the commonest things with which we are all familiar is a thing which we see on the telegraph posts all over the country. This is made of porcelain. We believe that by our stuff it can be made better and cheaper than by porcelain, and that it will replace the present porcelain article. We know that we supplied an order to the Post Office some time ago, and they have been sufficiently satisfied with it to ask us quite recently to make a tender to execute another order. Besides that there are almost an infinite number of things to which insulation is a requisite in electricity. We know thoroughly well how the development of the application of electricity to ordinary affairs is going on now, and we think we have got something which is a necessary ingredient in that application. If that is true, and I believe it is, we have got hold of a very good thing, and if the crop is properly nurtured, and the production is carried out in an economical and successful way, we ought to have got hold of a very successful business. It is however, to be tested by experience. As yet we have done little except lay the foundation, but now that we have got our requirements we hope to produce our stuff. I am a great believer in the thing myself. I have got a considerable stake in it. Though I belonged to the original parent Insulite Company, I have put not only what came to me from that, but a great deal more into this, and in reasonable time I feel satisfied that it ought to be a very fine property. An unavoidable delay has occurred in getting to work, but that fact is not a deteriorating or damaging one, and I hope the proprietors will so regard it. I believe I am expressing the opinion of the Board—certainly my own—when I say that there is no reason, so far as I am aware, to think that we have been injured by the delay. On the contrary, everything that we have done since, every step that we have made since (for steps are being continually made in the way of discovery about electricity), every step has convinced me of the value of this invention. We have Dr. Fleming, the inventor, a gentleman of the first scientific attainments, of high Cambridge distinction, of great knowledge and ability, here in this room, and he has perfect confidence in the invention. Whatever he may have got out of the sale of this patent, he is such a believer in the thing itself that he has put it into the Company, and Dr. Fleming will show you presently two or three methods by which this material can be turned to practical account, and in a way that no other material can practically be used, and I hope he will help to demonstrate the value of your property. Sir George Rickards reminds me that Sir William Thomson, a great authority in this matter, has written in the strongest terms of praise of this material. What Sir William has written has been sent round to the shareholders, and there is no reason to doubt the correctness of his views, which are thoroughly in confirmation of the views which we entertain ourselves. I now move "that the report and accounts be received and adopted," and I will ask Dr. Fleming to say a few words about this matter.

Dr. FLEMING, in the course of a very interesting address, said:—In response to your invitation, and with the consent of this meeting, I will offer a few remarks and give you a little information which I think I am probably better fitted to do than any one in this room on the probable commercial future of this material of which I am the inventor. I am perfectly aware of the proverbial sanguineness of inventors, but I also rise with a sense of responsibility to keep within the strictest limits of moderation in my remarks. I am the largest shareholder in this Company, and, as the chairman has said, not only that which we may have taken out of the original concern we have put back into the Company, but even more. I will now detain you for one or two moments in explaining to you how we expect to do a large business by the manufacture of certain articles with this material. I have here a series of samples of materials and articles we are

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making. We have not altogether been idle in the interval between our formation and the present moment. We have occupied ourselves with preparing a series of articles which we expect to supply in very large quantities. You have before you, first, Sir William Thomson's report on this material, to the effect that it is of exceptional value. You know also that it is formed of cheap and abundant raw material, and that the process of manufacture consists in pressing these materials into moulds, and manufacturing therefom any of these articles. Here is a Post Office insulator from a pattern supplied to the English Government, and they have had a very large number of these insulators. In addition to that, a considerable number have been supplied to the Duke of Sutherland for his telephone lines around Dunrobin Castle, and the experts who put them up speak highly of these telephone lines. We have an article here to be supplied at a price which can compete with stone, over which it has three advantages. It is not nearly so fragile, it is also very much lighter specifically, and every telegraph engineer knows the importance of getting an insulator, as light as possible. The third advantage it possesses is that it has a very much higher electrical insulating power than stone or porcelain. I am perfectly convinced, as soon as we can produce this insulite in sufficient quantities, that we shall have a very large business in that single article alone. Here is an ordinary battery cell made in thousands every day for telephonic and telegraphic purposes and for medical batteries. What are the objections to it? It is made of glass, and is very fragile. The Telephone Company break 25 per cent. of those they send out. Then they cannot seal a glass cell so as to make it perfectly liquid-tight. With our material we can make the cell very much lighter, very much stronger, and it has the great advantage that you can solder this insulite together. This battery, too, unlike one of glass, can be charged and sent out ready for use. You do not require to leave its charging to those to whom it is sent. This one is charged now. It is very strong. But if it is necessary to give these batteries a little additional strength, you can put them in a light tin case, which can be sent by parcels post ready charged. If you ask what it is that limits the use of electrical alarms, you find the reason is because people cannot be troubled with the difficulty of charging batteries. If you are living near a large town, that can be done with comparative ease, but not otherwise. We can make our batteries, too, in sets of one or two. These batteries (indicating several on the table) have been charged for a long time, and they can be thrown about, and they are perfectly uninjured by any ordinary usage. A battery cell like this can be made up with a bell, and so you can yourselves put up your electrical bell or burglar alarm at the window. Having given practical illustrations of this, he proceeded: I think in this business we have the monopoly. This cannot be done with glass. We have made up a large number of insulators of various descriptions. There are some telephone insulators. Here is an insulator which is being used to insulate the electrical railway which is to be laid down at Portrush by Siemens Brothers. I think that they will find when they come to use it that this is just what they want. They could not use ebonite on account of the price, or stoneware, or glass, as both would be too fragile. In this article alone I think we ought to look to getting a good business. But, passing on from batteries and insulators, there is another point of great importance which this Company has the power to do. Speaking as one who has something to do with electrical engineering, I can say there is a large demand for electric lighting which cannot be met up to the present. There is not one person in a thousand who would care for the trouble and expense of having a steam engine, boiler, and dynamos on their premises to produce electric light, and if they had it it requires constant vigilance on the part of some one to manage it, or the light would be going out. Now, even if they look to accumulators to do this, accumulators require to be charged by a dynamo machine, and to be carried backward and forward for that purpose. There is a battery lying on this table, and they can be made large as easily as they can be made small. It is only a question of the mould. We can make them of true shape, with certain grooves in the side, and then with putting in certain plates and chemicals, it is possible to make an installation of the electric light. This Company can supply that demand at once for the incandescent light. Having given a practical illustration of this, Dr. Fleming continued: We can, therefore, give people the privilege of having the incandescent light in their dining or drawing rooms by having a few insulated boxes, with the proper plates. Here must be a very large field of operations, and the moment we are in a position to supply this in large quantities, we shall be able to do an immense business in this article alone. The first twenty years of this century were occupied with the development of the steam engine for human purposes. The last twenty years of this century will certainly be marked by the industrial development of electricity. For that purpose a cheap and easily managed insulating material will be absolutely essential, and as soon as we have organised our factory and are prepared to turn this out in large quantities (and that is a matter I am giving personal attention to) I do not see how we can fail shortly to be doing a sound, progressive, and remunerative business.

In reply to a question, Dr. Fleming added that the cost of the electric light apparatus he had shown would depend on the number turned out. The larger the output the cheaper they could make them.

The Chairman, in reply to questions, thought that the property they had acquired at Charlton was in as isolated a place near a railway station as could be found. The fumes given off in the manufacture of the material were not unwholesome, and personally he did not think the smell disagreeable. He was told by the engineers that they ought to begin to make the stuff in about a fortnight or three weeks. He did not like to make a positive statement about the matter. He rather hoped that a call would be avoided for the present. He feared that his remark as to their business being speculative had been misunderstood. He considered anything speculative as to which there was a total want of experience, and the demand in connection with a new article must be a matter of the future. As to why the machinery had not been ordered before, they had first to get a place to put it in, and the apparatus, to a certain extent, had to be adapted to the place. The engine might have been adapted to any place, but as far as he had any opinion about the matter the engine was the thing about the acquisition of which it was probable there would have been the least difficulty. They had, however, as he had already intimated, had unexpected difficulty in obtaining one. At the request of the Post Office they had sent in a tender for certain work. He could not say that they had at present any large orders for battery cells. They could not apply for orders until they were ready to execute them. The insulators already supplied to the Post Office were paid for.

A Shareholder inquired why in that case there was no profit and loss account. He also saw that the item of "preliminary expenses" stood in the balance-sheet as an asset.

Mr. Price (of the firm of Price, Waterhouse, and Co., auditors of the Company), replied that no operations had yet been begun by the Company which could call for the production of a profit and loss account. The cost of the execution of the trial orders which had been received (and he might remind them that a trial order was given with the view to giving a larger order should satisfaction be afforded), and the money received from those trial orders had been dealt with in the current expenses. No accountant could prepare a profit and loss account of any company in such a case as this. The preliminary expenses, too, had not been put down as an asset, but as a means of showing how the money had been expended. Those expenses would have to be liquidated from profits in future years.

Mr. E. Harrison stated that, although he had been interested in what he had seen and heard at the meeting, the Company had been carried on in an unsatisfactory manner. They had been established nine months, and nothing had been done. There was no computation as to what they could turn out, or what the cost or the profit would be. Indeed, everything, in his opinion, was vague. He supposed, too, that the shareholders had seen the circular which had been issued by Mr. Arnold White, and he asked that gentleman whether he was going to take any action on it.

Mr. White replied that he should take his own course.

Mr. Harrison (continuing) again contended that there was a great dearth of information.

The Chairman, in reply, asked how was it possible to suppose that the manufacture of the material on a large scale was to be prosecuted, and all the necessary apparatus and plant got ready for the purpose at once. The prospectus itself stated:—"It is intended that a factory on a scale sufficient to meet the probable demand shall be at once erected." What they had to do could not be done all at once. Any one, with experience of public works must know that a considerable time was necessarily consumed in getting the requisite machinery and the whole of the plant set to work. He could not say how many tons a week could be turned out; but they had a very large quantity of the more costly material—something like £4,000 worth—and they hoped that there would be a large demand, and that they would meet it.

A Shareholder inquired whether it was not a fact that up to that moment, or nearly so, quite apart from the machinery, it had not been known to the Company how to prepare the material economically.

The Chairman: Oh dear no. It was known perfectly well at the time the patents were taken out, and the Company formed. There have been some improvement since, and Dr. Fleming is always making improvements.

Mr. Porter said that he knew nothing of the affairs of the Company except what he had learnt from the various circulars which had been sent to him, but it appeared to him that the Chairman had by anticipation answered the question just put. The Chairman had referred to the fact that they could now mould the material at once, whereas formerly it had to be made into blocks and cut as required. He thought it must be patent to all that that was a most material improvement, and must tend considerably to cheapen the process of manufacture. He thought that the information in that respect alone was very important, and gave them every reason not to regret the delay which had taken place. Again, every one with experience of machinery or new apparatus knew that delay was unavoidable. He knew nothing of the reason for the delay till he attended that meeting, but he thought that the explanations of the chairman had been decidedly satisfactory, and that the shareholders had every reason to think more of the process than they did when the Company was first established.

The Chairman, in reply to another question, quoted the clause in the Articles of Association of the Company relative to the amount of the directors' fees, which he reminded them again had not been taken. He had every reason to hope that for the present a call would be avoided—until they saw their way to large profits, and if a call were then made for an extension of the business he hoped it would not be regretted. Another point of importance as to the machinery was that it was so contrived as to save labour, and he believed that the greater part of the operations would be performed by unskilled labour, by women and children. Replying to other questions, he added that as regarded obtaining the largest portion of the material they required, sawdust, there would be no difficulty; and as regarded the other portion, he believed there would be no difficulty. It was a special material, but there were two or three substitutes for it. The Articles of Association provided only for annual meetings, but the directors and the shareholders had the power of calling other meetings. He thought they must be a little guided as to the circumstances, but, as far as he was concerned, he should be disposed to their having half-yearly meetings. He then put the resolution, and it was carried unanimously.

On the motion of Mr. J. Dummett, seconded by Mr. Edward Easton, the retiring directors, the Hon. E. P. Bouverie, Mr. M. M. Moore, and Dr. J. A. Fleming were re-elected to their seats at the Board.

A Shareholder then moved the re-appointment of Messrs. Price, Waterhouse, and Co. as auditors of the Company for the ensuing year.

A Shareholder, in seconding the motion, stated that a few days ago he met Professor Stuart, of Cambridge, who not knowing that he (the speaker) was at all interested in the Company, after speaking of Dr. Fleming in the highest terms, alluded incidentally to a remarkable invention of that gentleman of a substance called insulite, which he (Professor Stuart) thought of very great value, and for which he believed there would be a very great demand.

The Chairman put the motion, and having declared it carried, and announced that that closed the business, said he thought he might undertake on the part of the directors, that when they had made some little way, as they hoped to do, they would send round to the shareholders a circular as to the prospects of the business.

On the motion of Mr. Porter, a vote of thanks was passed to the chairman, and

The Chairman having expressed his acknowledgments, the proceedings terminated.

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ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION (LIMITED).

The adjourned meeting of the above Corporation was held at the City Terminus Hotel on the 5th inst., under the presidency of Sir H. W. Tyler, M.P.

The CHAIRMAN opened the proceedings by reading the report of the scrutineers on the poll demanded at the meeting on the 23rd ult., and taken on the 30th ult., on the amendment proposed by Mr. Gillitt, seconded by Mr. Allsopp, as follows: "That a committee of shareholders be appointed to consider and report upon the affairs, position, and general conduct of the Corporation." The shareholders claimed to vote in respect of 27,758 shares attending the adjourned meeting by proxy or in person. Votes in respect of 5,760 of such shares had been on investigation disallowed by the scrutineers, and he was told that of the shares disallowed about two-thirds were in favour of the directors and one-third in favour of the amendment.

Mr. GILLITT thought that was hardly so.

The CHAIRMAN: There were more in favour of the directors.

Mr. GILLITT assented.

The CHAIRMAN: In the result 22,088 votes were allowed by the scrutineers, of which 8,750 were in favour of the amendment and 13,338 were against the amendment, showing a majority against the amendment of 4,588 votes. This was signed by Cecil Coward, Alfred Gillitt, J. S. Sellon, and F. G. Stuart. He therefore declared the amendment lost. Continuing, he put the original resolution for the adoption of the directors' report and balance-sheet. On putting it to the contrary, there were several dissentients, on which

Mr. GILLITT stated that the objection was a mere matter of form on their part to show that their opinion had not altered. They were willing that the Chairman should announce that the resolution was carried.

The CHAIRMAN said that he must take the votes of the meeting, and having done so (without announcing the numbers) he declared the resolution carried. Continuing, he moved the confirmation of the appointment as a director of Lord Claud J. Hamilton, M.P. They were, he said, very sorry indeed at the beginning of last year to lose the services of one of their most valuable directors, Mr. Nettlefold. Mr. Nettlefold was a gentleman who had shown very great interest in the concern, but in consequence of a family affliction, and having the whole of a very large business left on his hands, he was obliged to resign his seat at the Board. They were therefore obliged to fill the vacancy, which they did by appointing Lord Claud J. Hamilton. The position and character, as well as the business capacity of Lord Claud, would be of the greatest use to the Company.

The VICE-CHAIRMAN (Mr. J. S. Sellon) seconded the motion, and stated that throughout the time Lord Claud J. Hamilton had held a seat at the Board he had been a most independent member of it.

The CHAIRMAN put the motion and declared it carried unanimously. He then moved the re-election as directors of Messrs. Sellon, Ladd, and Courtney. He observed that Mr. Sellon was very much interested in electric lighting, independently of any particular company. He was a most indefatigable worker, as, in fact, were all the directors, on behalf of the interests of the Company. There was hardly a Board meeting held at which they did not sit for six hours, in addition to having intermediate meetings. With regard to Mr. Ladd, that gentleman was one of the earliest labourers in the field of electric-dynamo machine work, and actually produced the first dynamo machine that was worked. Mr. Courteney, who was a barrister of high standing, was unfortunately absent in America.

Mr. HERBERT GIBBS seconded the motion, which

The CHAIRMAN put and declared carried.

Mr. NETTLEFOLD next moved the appointment of Mr. A. E. Jarvis as auditor for the ensuing year, observing that that gentleman had been auditor since the formation of the Company, and thoroughly knew the system of accounts.

Mr. BEDFORD seconded the motion.

The CHAIRMAN put it, and it was carried unanimously. Continuing, he said: I have only now one other resolution to propose—that is on a matter of special business—"That the directors be authorised to apply for an official quotation on the Stock Exchange in respect of 700 fully paid-up shares, numbered 40,001 to 40,700, inclusive, in the Corporation, issued to Mr. C. F. Brush, or his nominees." These shares were issued on the responsibility of the directors, and as it was entirely within their power to make the issue, we do not ask the shareholders to authorise the issue on this occasion. But it has been remarked to us by the brokers of the Company that to get an official quotation on the Stock Exchange of these shares, and to place them in the same category as the other shares, it was desirable to get the authority of the meeting to apply for an official quotation on the Stock Exchange. These shares were issued in May, 1882, as a matter of bargain with Mr. Montgomery, who was here at the time in regard to the Russian patent, the issue of which has been delayed for a very long period. We made in the matter what we believe a very good bargain in the interests of the shareholders.

The VICE-CHAIRMAN, in seconding the motion, said that there was not one of the shareholders who, if he knew the whole of the facts surrounding the issue referred to, would not approve its having been made. It was a most beneficial transaction for the Company.

The CHAIRMAN put the motion for approving the resolution.

Mr. LANE-FOX: May I ask a question?

The CHAIRMAN put the motion to the contrary, and declared it carried unanimously.

Mr. LANE-FOX wished to know if he might ask a question with regard to the issue of these shares.

The CHAIRMAN: It is too late: the resolution is carried.

A VOICE: It was not put.

Mr. GILLITT thought it was hardly worth while to have referred to the number of votes disallowed; but as they had been referred to by the chairman, perhaps he ought just say that, as nearly as he noted them down in going through the scrutiny, there were 2,100 and a few over struck off the votes given in favour of the amendment. That would leave about 3,600 struck off as against it. He thought that they would all feel satisfied that so large a number of votes were recorded out of the total, nearly 28,000 votes were recorded out of 40,700. That was quite as large a proportion as one would expect to find in any company, and as such it was a satisfactory expression of opinion of the body of the shareholders.

The CHAIRMAN observed that they were quite prepared to admit that the proportion Mr. Gillitt had indicated was correct. He formally announced that that closed the business.

Mr. NETTLEFOLD thought that they could not separate without passing a vote of thanks to the chairman for presiding ("No, no," and hear, hear). Coupled with that, he thought they ought to give their best thanks to the directors, who bestowed so much time, labour, and attention on the affairs of the Company. Gentlemen who had not been on the Board knew very little of the amount of trouble and attention that were given to the affairs of the Company by the directors. They sat at the Board every week from four to ten o'clock at night. Besides that they had constant committees; and, indeed, they would all understand the amount of work that was required from a board which had to promote an entirely new industry. Therefore, he contended their thanks were due to Sir Henry Tyler for presiding over the meeting, and also to the directors for their attention throughout their term of office.

Mr. ASH seconded the motion, which was carried.

Mr. BULLIVANT: I should just like to say a few words as a director, appointed by you two years ago, with others, to manage the Company, and I think, in justice to you, we should say what we have done, and how we have worked your Company since we started. You trusted us as directors with £238,000 of called-up capital to work this Company to the best advantage for you. With that we had to buy the Brush patent for pretty nearly all the world except America. We completed that, as instructed by you. We then found we had not quite a complete system of electric lighting, and we therefore thought it advisable to secure the incandescent lamp patent of Mr. Lane-Fox, which we did, our arrangement being that we should pay him £5,000 in shares of this Company, that he should participate in half of the money derived from the sale of foreign patents, and that he should also receive 25 per cent. of all the profits made upon the working of the incandescent business. Having done that, we thought, having completed our system, that we ought to make known our system of lighting throughout the world as far as we could. To do this we exhibited, as you know, at the Paris Exhibition. You must remember at that time electric lighting was not so well known as it is now, and we were anxious to show that the system we had was the best that was known, as certainly it is the best now known. We therefore went to considerable expense, and at the Paris Exhibition we exhibited sixty arc lights, running over a circuit which no other system could do, and with our machinery we lighted up there about 1,000 incandescent lamps. I think those who saw it will say that the way we exhibited these did credit to this Company. Then we were left to carry out this business, and we were left with the English patent. The question was, how should we work it? We knew that the capital we had then issued (£400,000) was quite an insignificant sum to work so large a district, and we therefore had to manage the best way we could, and we considered that we had better divide England and Scotland into different sections, and to sell concessions for those various districts. The result has been this, that there have been companies formed now, with good boards of directors, to work our system throughout England and Scotland, with an issued capital of above £1,500,000, and with an unissued capital, but authorised to be issued, of another £1,500,000. We thus stand, so far as England and Scotland are concerned, as a manufacturing company. We then began to look about and fit up works—we had started before—we fitted up the Portpool-lane works and also the Victoria works, and we found our business then was so great that we were obliged to take other works. We have now fitted up those works with the most improved modern machinery, and to enable us to supply apparatus for electric lighting on the very lowest scale. What have we done besides? We have returned you £275,000, and remember the paid-up capital is £238,000. Now, can you point to any other electric lighting company, or any other company at all, that has done anything like so well for their shareholders as we have done? Can you name any company ever formed that has established a business as has been established now to work your patent throughout England and Scotland; and whatever business is done (and no doubt it will be enormous) must bring profit to you. That electric lighting has for a time met with a check there can be no doubt, but it is very easily accounted for. Besides having many opponents as regards gas and so on, the Electric Lighting Act has for a time stopped work. At the present time it is not decided who shall give the light in the different districts—whether it shall be the local boards, or, if not these, whether it shall be done by a company, and, if so, what company. Till these questions are settled there is a check on electric lighting. But, as to the future of electric lighting, I do not suppose there is one in this room questions for one moment that the electric light is to be the light of the future, and, if so, is there any other company at the present time in anything like our position? Has any company anything like our system, or so good a system as we have? Then why have we been met here with a feeling of dissatisfaction among our shareholders? Had we had our original shareholders here they would have looked on us in a very different manner to what the present shareholders do. If we had the original shareholders instead of those who have been buying the shares at enormous prices there would have been no dissatisfaction with what the Board have done. Remember that we, as directors, have had nothing to do with the price of your shares. We have had nothing to do with that. All that we have to do, and are determined to do, is the best we can for the shareholders who have entrusted us with their capital, and I think I may say without question that no company has ever been formed that has worked better for their shareholders than we have for you. We work up to ten at night for your interests, and have done it with an amount of pleasure, as we felt our shareholders would be satisfied with us. Now we find we have a great many dissatisfied shareholders. For my own part I should have been delighted to work for satisfied shareholders, but I am determined not to work for dissatisfied shareholders. I shall, therefore, only remain on your Board until another director is found to take my place, and as soon as a gentleman can be appointed to my place I shall resign. I shall not work for shareholders who have shown such dissatisfaction. I think it is right that you should know what we have done since we were appointed, and I think it is also just to ourselves that we should state our position.

The CHAIRMAN: It only remains for me to return you thanks on behalf

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of myself and the Board for your expression of thanks, and to say that having got over our little difficulties for the moment our best services are now entirely at your disposal. We have had a check to our business, and a severe one for the moment, but we still believe in this business, and shall lose no opportunity of advancing your interests by any amount of energy we can bestow on the affairs of the Corporation.

THE TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on the 6th inst. at the offices, 38, Old Broad-street, Sir Daniel Gooch, Bart., M.P., in the chair, for the purpose of passing a special resolution approving a Bill now pending in Parliament, intituled "A Bill for removing doubts as to and for extending the powers of the Telegraph Construction and Maintenance Company, and for other purposes."

Mr. W. SHUTER (the manager) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen, we have called you together to-day for the purpose of asking your authority to a Bill which we have brought into Parliament this Session for the purpose of extending the powers contained in our Memorandum of Association. The powers now as mentioned there are "for the construction, laying down, and maintenance and working of submarine or land telegraphs and apparatus, the importation, manufacture, and sale of all materials, articles, and things in any way used in or connected with the construction, maintenance, and working of telegraphs." You will see from that at present our powers are limited very much to telegraphs alone, but since the formation of this Company you all know the use for electricity both for lighting and for other purposes has very much developed, and with the means at our disposal we think it is to your interest we should try to avail ourselves of what we possess in the shape of machinery and appliances to get some of the business connected with those other branches of electric departments. The Bill, which is a very short one, shall be read to you if you wish it. I need not read all the clauses of the Bill, because they merely set forth the position of the Company, but the clause which affects you is this. (The clause, here read by the chairman, referred to the power which it was proposed to confer on the Company in regard to electric lighting.) The necessity of the Bill arose from the fact that you cannot alter your Memorandum of Association by the act of the shareholders. To enable you to do that it would be necessary to wind up the Company and establish a new company under new Articles of Association, and, therefore, we go to Parliament as the only other alternative for the purpose of enabling us to accomplish that object. I do not know that I need say more to you now, and I therefore move—"That the Bill now pending in Parliament, intituled a Bill for removing doubts as to and for extending the powers of the Telegraph Construction and Maintenance Company (Limited), and for other purposes be, and the same is hereby approved, subject to such additions, alterations, and variations, if any, as Parliament may think fit to make therein."

Sir GEORGE ELLIOT, Bart., M.P.: I have much pleasure in seconding that.

The resolution was put, and carried unanimously.

The CHAIRMAN said that, of course, the resolution would have to be confirmed, and that it would be done at the next general meeting.

Mr. W. ABBOTT: Well, sir, before separating, allow me to say a few words. The resolution was carried, I have no objection to it, I am sure the proprietors present are not likely to have any objection to it, because it is carrying out a principle which I took upon myself to suggest at a previous meeting, that this company, with its great reputation, its large capital, and its extensive staff of gentlemen well versed in the knowledge of electricity should identify itself more with electric lighting, and other appliances connected with electricity. I am, therefore, very pleased indeed, sir, that you have carried out this suggestion which I made some year and a half ago. It may appear somewhat late in the day [hear, hear]. A gentleman says "hear, hear," but I am the first to come before you "with the candle and white sheet," and renounce my former opinion that you should have proceeded precipitately in carrying out the principle of electricity. When I was down at the Crystal Palace, several times I saw Sir Daniel Gooch moving about the electrical departments, and I thought that something would be up very likely, and that the Telegraph Construction and Maintenance Company were about to identify themselves with the electric light, but I know your characteristic caution. You have proceeded with caution, and therefore you are much more likely to be successful, as you have the experience now which other companies have given you, and you are very much more likely to make this new enterprise profitable. I think it is only right, as I had suggested it, I should say I commend you for the caution you have shown, and I have no doubt it will result in considerably more profit than if you had gone into the vortex of speculation through which so many companies have suffered during the past year [cheers].

The CHAIRMAN: If no other gentleman has anything to say, that concludes the business of the meeting.

Mr. W. ABBOTT: I beg to propose a hearty vote of thanks to Sir Daniel Gooch and the other directors for what they have done for us up to the present time.

The resolution was seconded and carried.

The CHAIRMAN: Gentlemen, we are very much obliged to you for your confidence, and shall do our best to merit it.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending February 2nd, 1883, were £2,638, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).

Directors' report for the year ending December 31, 1882, to be presented at the nineteenth ordinary general meeting of the shareholders, to be held at the City Terminus Hotel, Cannon-street, London, on Tuesday, the 13th February, 1883, at 12 o'clock noon. The directors have much pleasure in stating that every department of the Company's business has been well employed during the past year. On reference to the annexed accounts a large reduction will be observed in the item debentures and shares in other companies. The year's sales of these securities have realised a considerable profit. The net profit amounts to £192,784 9s. 6d. Adding £21,526 17s. 9d. brought forward from 1881 and deducting £15,600 interim dividend paid in July, there remains a disposable balance of £198,711 7s. 3d. The directors have added £100,000 of this balance to the reserve fund, raising it to £200,000, and they now recommend the distribution of a dividend of one pound per share and a bonus of £1 per share, amounting together to £62,400, and making, with the interim dividend, a total payment for the year of 25 per cent., free of income-tax, carrying forward £36,311 7s. 3d. To enable the company to meet the demands of an increasing business, considerable sums have been and are being expended on the construction of buildings and machinery at Silvertown and at Persan-Beaumont, and additional land has been acquired for the necessary extension of the Persan factory, and for obtaining access to the railway. For these purposes, and to provide further working capital, the directors have deemed it necessary to make the addition to the reserve fund stated above. In the cable department contracts have been carried out for the French and Canadian Governments, and for the Central and South American, Mexican, Direct Spanish, West India and Panama, and Western and Brazilian Telegraph Companies. The cables which the company contracted to lay have been successfully completed under the able management of the Company's engineer, Mr. Robert Kaye Gray; and he and the entire staff are entitled to the highest commendation. The directors have for some time felt it to be very desirable that accommodation should be provided for the comfort, instruction, and amusement of the workpeople at Silvertown. They will, therefore, submit a resolution at the coming meeting authorising the expenditure of a sum of £6,000 for the erection of a hall and dining rooms on the Company's property. Further details will be given at the meeting.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES FEB. 7.		BUSINESS DONE WEEK ENDING FEB. 7. Highest.		Lowest.	
Anglo-American	50½,	51½	51⅛		50⅛	
Do. Preferred	83,	84	83⅛		82	
Do. Deferred	18½,	19	19⅛		18⅛	
Brazil Submarine	12½,	12⅝	12 5-16		12⅛	
Cuba	10,	10⅛	10⅛		10⅛	
Do. Preference	17,	18	—		—	
Direct Spanish	6⅛,	6⅞	—		—	
Do. Preference	16,	17	—		—	
Direct United States Cable	12⅛,	12⅜	12 5-16		11⅜	
Eastern Telegraph	10⅞,	11⅛	11⅛		10 15-16	
Do. 6 per Cent. Preference	13,	13½	13½		13⅛	
Do. 5 per Cent. Debentures, 1899	103,	106	105		104⅛	
Eastern Extension	11⅛,	11⅜	11⅛		11⅛	
German Union	10,	10⅛	10 11-16		10 11-16	
Globe Telegraph and Trust Company	6⅛,	6⅞	6⅞		6 9-16	
Do. Preference	12⅛,	12⅜	12⅜		12 11-16	
Great Northern	12,	12⅛	12⅜		12 1-16	
Indo-European	32,	33	32⅜		32⅛	
Mediterranean Extension	1⅞,	2⅛	1 13-16		1 13-16	
Do. Preference	6,	8	—		—	
Reuter's	10½,	11	10⅝		10⅛	
Submarine	255,	260	256		253	
West India and Panama	1⅛,	1⅛	—		—	
Do. 1st Preference	7,	7⅛	—		—	
Western Brazilian	7⅛,	8	8		7⅛	
West. Union 7 per Cent. 1st Mortgage	122,	126	—		—	
Do. 6 per Cent. Sterling Bonds	102,	105	—		—	

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	¼	¼		11-16
Oriental	⅛,	¼	¼		11-16
United Telephone	10',	11	10⅜		8⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	6,	6½	7⅛		6⅛
Do. (fully paid)	9⅛,	10⅛	11⅛		10⅛
Hammond Light	3⅛,	3⅜	4		3⅛
Eastern Electric (£4 paid)	1,	—	—		—
Pilsen, Joel, and General Electric	⅜,	1⅛	—		—
Swan	2⅛,	2⅛	2⅛		2⅛
Maxim-Weston	⅛,	⅜	5-16		⅜

TRAFFIC RECEIPTS FOR JANUARY, 1883

COMPANIES.	Jan., 1883.	Jan., 1882.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	3,021	—	221
Direct Spanish Telegraph Company	1,689	2,055	—	365
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	32,822	33,129	—	307
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	18,240	17,110	1,130	—

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SLIP

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended February 9 were £3,876.

ANGLO-AMERICAN BRUSH CORPORATION.—Sir Henry W. Tyler, M.P., has resigned the office of chairman of this company.

ELECTRIC LIGHT FOR LOS ANGELES, CALIFORNIA.—The city council of Los Angeles have resolved to adopt the electric light for their streets.

ELECTRIC LIGHTING IN THEATRES.—It is stated that the Théatre du Parc in Brussels will be wholly lighted by means of incandescent lamps at the end of the present month.

NEW BOOK.—We have received a copy of the second volume of Senor Antonio S. Saavedra's "Estudio de la Electricidad del Magnetismo y del Electro-magnetismo," Second Edition.

ELECTRIC LIGHTING IN BRUNN, AUSTRIA.—The Edison Company are installing 250 lamps in a woollen factory at Brünn. The work is being done under the superintendence of Mr. Francis Jehl.

ABANDONMENT OF A PROVISIONAL ORDER.—The Pilsen, Joel, and General Electric Lighting Company have withdrawn their application for a provisional order, deposited with the Board of Trade under the Electric Lighting Act, with regard to the City.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending February 9, 1883, were £2,542, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

NEW COMPANIES.—The Electric Supply Company, of San Francisco, has filed articles of incorporation with a capital of 60,000dols. Articles of Association of the New York and Brooklyn Electric Light Company have also been filed; capital, 25,000dols.

LONDON PLATINO BRAZILIAN TELEGRAPH COMPANY.—The revenue of this company for the month of November, 1882, is estimated at £1,936 (Western Brazilian portion £1,433, land lines £503), as against £1,796 for the corresponding period of 1881.

ELECTRIC LIGHTING IN RUSSIA.—The agent of the Edison Company in Russia, Mr. E. Fedor, has recently fitted up machines and lamps in the following towns, viz., Tammerfors, Helsingfors, 60 lamps in a tapestry factory, and Lorefow, 240 B lamps in a sugar factory.

PROPOSED EXHIBITION AT HUDDERSFIELD.—The Huddersfield Technical School and Mechanics' Institute are going to hold a Fine Art and Industrial Exhibition in June next. Motive power will be provided free of expense. Applications for space must be sent before 21st inst., to Mr. A. Keen, secretary, Huddersfield.

ELECTRIC LIGHTING AT HAMPSTEAD.—The Vestry of Hampstead have been considering the provisional orders which concern their parish. They do not seem to be very favourable to the Metropolitan Brush Company, one of the applicants for an order, but look more favourably on Messrs. Ferranti, Thomson, and Ince.

THE PILSEN LAMP.—We understand that the Science and Art Department of South Kensington have just given an order to the Pilsen, Joel, and General Electric Light Company for twelve Pilsen arc lamps, and the necessary dynamo machines. This order has been given after a careful trial of the working of a Pilsen lamp.

PUMPING WITH DYNAMOS.—The Electric Carbon, Storage, and Apparatus Manufacturing Company, of Leith, inform us that they have just concluded arrangements to do the pumping at the Marquis of Lothian's collieries at Dalkeith by electricity with one of Dr. Higgs's dynamos on the surface, and Dr. Higgs's improved motor below ground.

EXHIBITION OF METEOROLOGICAL INSTRUMENTS.—The Council of the Meteorological Society have determined upon holding at the Institution of Civil Engineers, 25, Great George-street, S.W., on the evening of March 25 next, an exhibition of meteorological instruments which have been designed for, or used by, travellers and explorers.

ELECTRIC LIGHTING IN BELFAST.—The premises of Messrs. Keys Brothers and Sims, of Donegal-street, Belfast, have for the last month been lit up by four Pilsen arc lamps, one outside and the rest inside the building. The lights have been put up by Messrs Woodhouse and Rawson, and have given every satisfaction, people being much surprised at their steady working.

TASMANIAN TELEGRAPHS.—From some statistics of the progress of the colony of Tasmania between the years 1871 and 1880, published by the Government statistician, it appears that telegraph stations show an increase of 349 per cent., miles of wire 299 per cent., numbers of messages 429, and amount received 555 per cent., the increase in expenditure being only 215 per cent.

ELECTRIC LIGHTING IN BRUSSELS.—The House of Parliament in Brussels has been partly lighted for the last few days by means of Edison's system. One hundred lamps are distributed throughout the hall of assembly. The engine used to drive the dynamo is one of Messrs. Robey's of Lincoln. The installation was carried out by the Compagnie Générale d'Electricité, under the superintendence of M. Nothomb.

AYRTON AND PERRY'S EXPERIMENTS WITH PLATINUM AND MAGNESIUM.—Writing on the subject of Professors Ayrton and Perry's experiments with platinum and magnesium strips dipping into mercury, whereby they obtained a current, M. B. J. Goossens shows in the *Annales Phys. Chem.* that the current thus obtained is caused by the evolution of heat in the formation of the magnesium amalgam, and is, therefore, a thermo-current.

GAS IN PARIS AND LONDON.—In a recent lecture delivered by M. H. Aerts, manager of the Brussels Municipal Gas Works, the following comparison between Paris and London gas was instituted:—"The Paris burner consumes 105 litres, or nearly 4 cubic feet per hour. The London burner consumes 142 litres, or nearly 5 cubic feet per hour. The illuminating power required in London is 16 candles for 142 litres (5 cubic feet) of gas. The normal illuminating power of Paris gas, consumed in London burners, corresponds to 15·2 candles."

ELECTRIC RAILWAYS.—Electric power as a means of traction on railways seems to be gaining ground every day. We have instances at Berlin, some mines in Germany, Portrush (Ireland), and elsewhere. Electric railways are talked of in Switzerland and Vienna, and now we hear that the Chicago Town Council has been memoralised by a Mr. Hannahs on the subject. Mr. Hannahs wants to erect an elevated rail-

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way in Chicago, the motive power on which shall be supplied by electricity, whilst the carriages will be lighted by the same agency.

Electric Lighting for War Vessels.—The French Government have, it is stated, determined on supplying a number of their men-of-war with Gramme machines and lamps, the latter provided with Mangin reflectors. Steam launches belonging to men-of-war are to be furnished with powerful arc lamps. Already several ships have been fitted up internally with incandescent lamps. Amongst these we may mention the Redoutable. Gramme machines, driven by Brotherhood engines, supply the current to the lamps, which in this case are Swan's. It is probable that the Océan, another ironclad, will be lighted by means of Edison lamps.

"Journal of the Society of Telegraph Engineers."—We have received a copy of the January number of this journal. Amongst other things, it contains Mr. Preece's paper on "The Munich Electrical Exhibition, 1882;" Colonel Webber's paper, entitled "Notes on the Telegraphs used during the Operations of the Expeditionary Force in Egypt." Of original communications there are three, viz., one from Mr. Preece on "Recent Progress in Telephony;" one from Mr. John Gott on "The Mirror Galvanometer and Scale;" and one from Mr. Fred. A. Hamilton on "Slipping Buoys from Cable Ships." The abstracts from foreign periodicals contain matter of interest.

Electric Lighting in Chelsea.—At a meeting of the Chelsea Vestry, on Tuesday, a letter was read from the Board of Trade, in which it was stated that the Chelsea Electric Lighting Provisional Order promoted by the Metropolitan (Brush) Electric Lighting Company would be considered to-day (Saturday). The matter was referred to the Electric Lighting Committee, who were empowered to take all necessary steps for the protection of the interests of the parish. It was stated that this is the first case to be taken under the Electric Lighting Act, and it was understood that the vestry would be represented by Mr. C. Mossop, the chairman of the Electric Lighting Committee, and Mr. G. H. Stayton, C.E., the surveyor to the vestry.

The Transmission of Power.—The subject of M. Marcel Deprez's experiments occupied the attention of *The Times'* Paris correspondent this week. We have already expressed our opinion on these experiments, and would not refer to them again, but for the sanguine way in which the above correspondent treats the matter. He says, "In one of the experiments the force was transported 35 kilometres, and having been of 10 horse-power at the starting point, it was still 5 horse-power at the point of arrival." We think *The Times'* correspondent is mistaken, and until we are proved to be wrong, must reiterate our previous statement, founded on the evidence of eye-witnesses of the experiment, that not more than one-third, if so much, of the horse-power put into the sending machine came out of the receiving one.

Reinforcing Telephonic Currents.—At a recent meeting of the French Physical Society, Mr. James Moser communicated his method of reinforcing telephone currents. It consists in connecting induction coils and receivers, partly in series and partly in quantity, like the elements of a battery. For example, in transmitting music from the Hippodrome to the Place Vendôme, on a recent occasion, Mr. Moser joined up 24 coils as follows:—4 in series, 6 in quantity; and 100 receiving telephones, 6 in quantity and 16 to 18 in series. Two theories point to an arrangement of the induction coils in opposition to one another; tension is necessary in order to get the maximum return and useful effect, and quantity is necessary in order to get the minumum lateral losses, condensation, absorption, &c. In fact, Mr. Moser's plan is to arrange the elements of telephonic circuits in the same way that the elements of a battery are arranged in order to obtain the greatest effect.

The Grievances of Telegraph Clerks.—A meeting of telegraphic clerks employed at the Exeter post-office was held in that city on Saturday last, for the purpose of considering the scheme of revision lately applied to the telegraph service, especially as it affected Exeter. The meeting was largely attended, and resolutions were unanimously carried expressing dissatisfaction with the scheme, inasmuch as it had failed in many important particulars to satisfy the just claims of the telegraph clerks as advanced in their petition to the Postmaster-General in 1881. It was also resolved to support the central committee of the Telegraph Clerks' Association in its proposed attempt to obtain sanction for a Parliamentary Committee of Inquiry into the many questions affecting the welfare of the telegraph service which still remain open, and to use every other legitimate means to obtain a concession of the claims put forward. A meeting of telegraph clerks was also held in Newcastle on the same day, when resolutions of a similar character were enthusiastically passed.

Spectrum of Carbon.—In a recent communication to the Royal Society, Professors G. D. Liveing and J. Dewar communicated the results of spectroscopic investigations of carbon. Photographs were taken of the spark of a large induction coil between poles of purified graphite in air, carbonic anhydride, hydrogen, and coal gas; the wave lengths were determined by a Rutherford diffraction grating, having 17,296 lines to the inch, and found to be for the principal lines—2,296·5, 2,478·3, 2,509, 2,511·9, 2,836·3, and 2,837·2. When the spark was taken in air, the photographs showed, besides the carbon lines above, the six cyanogen flutings in the blue, and those between K and L, and near N, but this practically disappeared when carbonic anhydride was substituted for air. The spectrum of Swan's incandescent lamps was examined and found to be continuous until the thread gave way, when the characteristic green flutings of carbonic oxide appeared; in some cases a sort of flame appeared at the positive electrode when the current was not quite intense enough to rupture the thread The spectrum of the rarefied atmosphere within the envelope of the lamp revealed the presence of carbonic oxide. By interposing different flames between the incandescent lamp and the slit of the spectroscope, a comparison could be made of the probable temperature of the flames and filament, and from the experiments it is inferred that the emissive power of the carbon thread for light of the refrangibility of the D lines is approximately balanced by that of sodium at the temperature of the flame of cyanogen burning in air, but is sensibly less than that of sodium at the temperature of a jet of coal gas or hydrogen in oxygen. It is thus probable that the temperature of the incandescent thread is not far different from that conveyed to sodium by the cyanogen flame burning in air.

The Mirror Galvanometer and Scale.—In the January number of the *Journal of the Society of Telegraph Engineers* Mr. John Gott describes the following new scale for use with the mirror galvanometer, which he has found to answer well, and render inappreciable movements of the mirror visible. "Select," he says, "an ordinary toilet mirror—the clearer the glass the better; this quality can best be judged of by removing the frame and holding the

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glass up to the light and looking at the edge; if it has a deep blue tinge reject it. The thinner the class the better—one-tenth of an inch is a good thickness. The backs of some mirrors have a coating of varnish, and these are to be preferred, as less likely to have the silvering damaged by friction in handling. Cut off a strip 2½in. or 3in. in width, and, say, 15in. long. The surface of this is to be frosted by rubbing with a piece of glass about an inch square, supplied with fine emery powder and water; a small handle may be cemented to this piece with Chatterton's compound. After the frosting is completed, the strip may be framed with dark wood, and hinged at the back to a rod, so as to be movable around its centre, elevated or lowered, and inclined—in fact, it should have a universal motion, so that it can be adjusted to any focus. When the scale is five or six feet from the galvanometer (the lamp with its lens being, as is usual, much nearer), the spot may be said to be equally bright at all parts of the scale. For shorter ranges it is desirable to use a scale bent to form an arc of a circle whose centre is the galvanometer. Such a scale can be graduated by engraving on the glass; but as the frosted surface can be written upon with a fine pen and ink as readily as upon paper, any grading can be adopted, and, if necessary, be removed by washing. Transparent scales have been for some time in use; this reflecting scale possesses advantages over them which are obvious."

Magnetic Observations at Kew Observatory.—We take the following from the report of the Kew Committee of the Royal Society:—"The Magnetographs have been in constant operation throughout the year. In March a new suspension pulley was fitted to the bifilar magnet in order to reduce the distance between the suspension wires from 6·8 millims. to 5·5 millims., and thus to increase the sensibility of the instrument. This change was recommended by Professor W. G. Adams, in order to make the scale-value about ·0005 millim. mgrm. for 1 millim., as suggested in his report to the British Association last year. Dr. Wild, of St. Petersburgh, also recommends that all observatories should adopt, as far as possible, the same uniform scale for their instruments, and suggests that the scale-values should be as follow:—For the declination, 1 mm. $\delta D = 1'$; for the bifilar, 1 mm. $\delta H = 0{\cdot}0005$ mm. mgr. units; for the balance, 1 mm. $\delta V = 0{\cdot}0005$ mm. mgr. units. The following are the values of the ordinates of the various photographic curves as determined at the various dates stated:—Declination 1in. = 0° 22′·04. 1 mm. = 0° 0′·87. Bifilar Jan. 3, 1882, for 1in. $\delta H = 0{\cdot}0450$ foot grain units; for 1 mm. $\delta H = 0{\cdot}0008$ mm. mgr. units; bifilar Mar. 27, 1882, for 1in. $\delta H = 0{\cdot}0222$ foot grain units; for 1 mm. $\delta H = 0{\cdot}0004$ mm. mgr. units; Balance Jan. 6, 1882, for 1in. $\delta V = 0{\cdot}0341$ foot grain units; for 1 mm. $\delta V = 0{\cdot}0006$ mm. mgr. units. The committee having been asked by the secretaries of the International Polar Commission to furnish that body with copies of their hourly determination of the magnetic elements, recommenced the tabulation of the curves which had been suspended in 1879. (See Report for 1880, p. 4.) With a view, however, of reducing the labour of tabulation, it was decided that a sufficient degree of accuracy and greater rapidity would be obtained by reading the curves by the unassisted eye, without the aid of the tabulating frame and vernier hitherto employed. Scales graduated on glass plates have, therefore, been prepared; and the curves tabulated from August 1 up to the present date by this means, the declination being recorded to a tenth of a minute of arc, and the force-traces to the tenth of a millimetre. In order to obtain a record of the more rapid changes which take place during magnetic storms, a trial has been in progress since July 4 of the highly sensitive argentic gelatino-bromide photographic paper prepared by Messrs. Morgan and Kidd. The results of the experiment show that the paper indicates clearly small movements of the magnet which the waxed paper is unable to register, and also that less gas-light is needed for the purpose of illumination."

Electric Railways and Electric Lighting.—At a recent meeting of the Institution of Civil Engineers of Ireland, on the occasion of a discussion on Mr. Fahie's paper on dynamo machines, some interesting statements concerning both electric railways and electric lighting were made. We extract the following from a report which appeared in an Irish newspaper:—"Dr. Traill said that the principle on which their cars (on the recently-constructed Portrush Railway in Ireland) was running was not exactly the same as that on which the little machine before them was moved. Their first experiment was on that basis (using one rail for the positive and the other for the negative current), though they could hardly have anticipated that it would be possible to send a current through one rail and down another a distance of six miles. If the wheel of the car met with an interruption the current might be broken. When they passed one mile they saw they could hardly depend for conducting power the rest of the distance, and what they did was this—they put down a third rail, about 18in. high, a little on one side, and they had that rail completely insulated for a distance of 2½ miles. They found that paraffin oil and sawdust formed a complete non-conductor of electricity. Even in the wettest weather the insulation for 2½ miles was uninterrupted, and he had not the slightest doubt that before long it would be equally perfect for the whole distance of six miles. Their large car was about three tons weight, and they ran those cars on an ordinary up-and-down-hill road, the incline on which was in some places 1 in 35 and 1 in 40. Within a few months, when they applied water to generate the current, he believed they would be able to run their cars the whole distance, and that the success of the railway was assured.—Mr. Aspinall said that electricity had done a great deal for gas. But for electricity they would not have those magnificent burners which they now see in various places. He could tell them what had been done at the Great Southern and Western Railway Works within the last eighteen months. They were lit entirely by electricity, and one great reason for their success was this, that they had not got gas to fall back upon, and they were obliged to depend on the electricity. They had six dynamo machines running there—four small ones and two large—and each of the latter was able to drive a light equal to 3,000 candles. The light was used in the workshops, and for shunting purposes it did extremely well. He should be sorry to go back to gas, unless they got an equivalent light. As to the question of expense, an equal amount of light from gas would cost them a great deal more. Taking the expense of working, of coal fuel, the maintenance of machines, men's wages, interest on capital expended, it did not cost them for each hour they ran the light more than 8s. If Mr. Browning (engineer to the gas company) wished he would show him the cost of machines, from the first moment of their being worked down to the present."

Action of Currents on Chlorides and Chlorates.—The following abstract of a paper on this subject by Messrs. A. Lidoff and W. Tichonieroff in the *Journal of the Russian Chemical Society* for 1882, pp. 341-9, appears in the February number of the *Journal of the Chemical Society*:—"In a former paper the authors have found that by the action of

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the electric (galvanic) current on a solution of chlorides, hypochlorites are first formed, which by an elevation of temperature are converted into chlorates. But later on they found that even at the ordinary temperature, as soon as the solution becomes more concentrated, hypochlorites are converted into a mixture of chlorate and chlorides by the sole action of the current. They propose to apply this process to the manufacture of chlorates, more especially of the sodium salt, which is difficult to prepare in the ordinary way. On acting with a current of a powerful Gramme machine for 25 hours, on a solution of 400 grams of potassium chloride in 900 grams of water, 210 grams of crystals, 70 per cent. of chlorate was obtained. The crystals contain, together with potassium chlorate, a considerable quantity of the chloride, and 5-12 per cent. of carbon from the electrodes. As soon as about 30 per cent. of the original salt is transformed into the chlorate, the positive electrode is most strongly corroded, and no further separation of the crystals from the liquids takes place. If, instead of a high tension current (2 electrodes), a divided current (8 electrodes) is employed, far less chloride is converted into chlorate in the same space of time. The corrosive action of the liquid on the positive electrode is due to its oxidation by the oxygen of the potassium chlorate, which is reduced to chloride (about 30 per cent. in 10 hours). For this reason potassium chloride cannot be completely converted into chlorate, but a limit is reached after some time, when the energy of formation of potassium chlorate from the chloride becomes equal to the energy of its decomposition. Electrodes of another material than carbon cannot be used for the conversions of chlorides into chlorates, for all metals, even platinum, are corroded by the chlorine which is set free at the same time. If, however, a solution of potassium *chlorate* be electrolysed by means of platinum electrodes, no chlorine, but *ozone*, is evolved on the positive pole. At the same time crystals of potassium *perchlorate* separate from the liquid, and only traces of potassium chloride are formed at the same time. In this respect the action of electricity on potassium chlorate is analogous to the action of heat on the same salt; in both cases oxygen is evolved, and potassium chlorate and chloride are formed, although the proportion in the quantities of these two salts is widely different. The corrosion of carbon in the above case is due to the action of ozone, and the products of this action in presence of water are mellitic and hydromellitic acids."

Will a Current Traverse a Vacuum?—In the *Philosophical Magazine* for this month will be found a translation from the *Kongliga Svenska Vetenskaps Akademiens Handlingar* of Professor E. Edlund's "Researches on the Passage of Electricity through Rarefied Air." At the beginning of this paper Professor Edlund says:—"If r is the obstacle to the propagation of electricity which is situated at the point of passage between the electrodes and the gas, r_1 the electric resistance in a column of gas of unit length, and l the distance between the electrodes, $r + r_1 l$ will be the sum of the resistance which the electricity must overcome in order to pass from one electrode to the other. Of these values, r increases continually in proportion as the gas is rarefied, while r_1 during the same time undergoes incessant diminution. From a judicious interpretation of the experiments which have been made, especially those of Hittorf, it follows that the augmentation of the first of these quantities and the diminution of the other continued until the gas had arrived at the greatest rarefaction it was possible to obtain by means of the mercury pump employed. In the space exhausted of air, r acquires such a value that it is impossible for the current to surmount it. If, then, the current cannot traverse a vacuum, it is not because the value of r_1 of the resistance has become too great, but because r is augmented to such a degree that the current is incapable of surmounting it. Several properties of gases with respect to the passage of electricity show that this interpretation of the resistance which they oppose to its propagation is really the only true one." Dr. Edlund then goes on to repeat an opinion previously expressed by him that "the principal obstacle encountered by the electric current at the surface of passage between the electrodes and the rarefied gas is due to an electromotive force producing a current in the opposite direction to the principal current." Having described a number of experiments undertaken to prove the correctness of his opinion, Professor Edlund concludes by reasserting it, and says:—"It has been observed that the negative pole is strongly heated in a space of rarefied air, and that, *cæteris paribus*, this heating is augmented with the rarefaction of the air. I have, in a previous memoir, proved that, when a current traverses an electromotor in an opposite direction to the current which the electromotor tends to produce, there results from it an evolution of heat proportional to the electromotive force multiplied by the intensity of the current. Now since (according to what precedes) the electromotive force e in the spark is notably augmented with the rarefaction, it follows that the heat evolved at the negative pole must be increased when the rarefaction is increased, which accords with the results of experiment. Here it should be remarked that in the voltaic arc it is the positive pole that is most strongly heated, from which we may be authorised to conclude that the electromotive force, shown by irrefutable proofs to exist in the voltaic arc, has its seat at the positive pole. This force is not thermo-electric, and it is not produced, as M. Le Roux assumes (vide *Comptes Rendus* XCII., p. 710, 1881), by one of the poles being more highly heated than the other. On the contrary, it is the electromotive force that is the cause of the heating. It has been proved that the force continues to exist, even if the negative pole of the voltaic arc be heated by a Bunsen burner, or in any other way, so as to become hotter than the positive pole. The researches of which I have just given a brief summary confirm, therefore, in all respects, the results to which I had already been led by my examination of the observations of other physicists on the passage of electricity through rarefied gases. The maximum attained by the current-intensity at a certain pressure of the air when a current traverses a space of rarefied air is not due in any way, as it has been generally assumed to be, to the resistance $r_1 e$ of the air having its minimum at that pressure, and afterwards increasing in amount with the increase of rarefaction, but really to this—that the sum $e + r_1 e$ then possesses its minimum value. With the continuation of the rarefaction the resistance $r_1 e$ continues to diminish, while e incessantly increases; consequently the circumstance mentioned above, namely, that the induced current possesses its maximum value at a certain pressure of air, gives no support to the allegation that in highly rarefied air, or in a vacuum, the resistance is sufficiently great to prevent the current passing. Here it is not the resistance of the gas, but the electromotive force e_1 increasing with the rarefaction and connected with the electrodes, that presents an obstacle to the passage of the current. Everything is in favour of the hypothesis that vacuum opposes a very feeble resistance to the propagation of electricity."

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

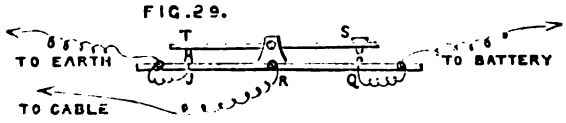
No. XIV.

The form of arrangement for the connections in the joint test suggested in the two last numbers may be open to objection on the ground of having more contact points than are absolutely necessary, and a comparison with the figures given in this number will afford a means of determining the question which plan is likely to present the fewest obstacles to good insulation, and to avoid any interference of one section of the operation with another. Facilities in connecting up need not be taken into account, for we have supposed the arrangement to be made specially with a view to confining it always to this one purpose, and when once in order at the commencement of manufacture of a long cable, to remain unchanged to the end.

The first of the two diagrams of connections shows a mode of joining up with one earth communication, and the second is much the same, but there is no connection with the earth. Many operators prefer this latter arrangement, for reasons which will presently appear. Let us examine Fig. 30, and see how the objects attained with the connections in the former figures are gained by means which at first sight appear to be different.

We have here, as in the first plan, two separate keys. In Fig. 23, &c., there were practically two Lambert keys, one of which served to charge and discharge the cable, and the other was employed for observing the action of the trough (or the water) in their relation with the joint. The two keys in Fig. 30 exactly replace these other two in one view; one of them is a Lambert key, and the other, properly speaking, is a discharge key. Figure 29 gives a view of its action

FIG. 29.



Side View of Key in Fig. 30.

which might not be so clearly apparent in the smaller illustration. The stand is of insulating material, and the brass bar is pivoted at R, where connection with the cable is made, and has two contact points, that at J being, in the key's normal position, in contact with a similar point which connects to earth. At Q a contact which connects one battery lead brings the latter into communication with the brass bar when depressed, and the other battery pole being to earth through J, a charge is thus sent into the cable through the point R. The Lambert key has a connection F, which enables us to put the trough directly to earth, which may pass for an advantage compared with the first arrangement, where it could only be earthed through the galvanometer.

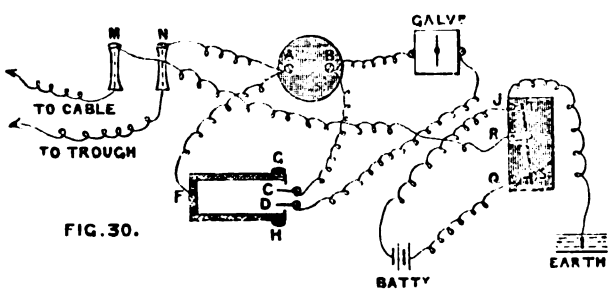


FIG. 30.

Joint Test; One Earth Connection.

The conditions, however, would be equal if the galvanometer in Fig. 23 had a short-circuit arrangement, which we have not represented, because for this purpose, with the plan there suggested, another key or connecting piece would have been necessary. In the case now before us the point G is kept down on C during the interval between tests, but not with the object of putting the trough to earth. This contact is only necessary for a reason referred to in our remarks on the test in the last number. It answers the same purpose as having a plug for joining the two poles of the condenser. When G is not put down the poles are separated, but by depressing G on C, the lead (A F G C B) joins the poles, and both are put to earth by the earth lead wire. The condenser in this figure may be supposed to have no plug arrangement. Another point in which this plan differs from the first is that the cable is kept to earth at every moment except when it is charged, that is to say, of course, from the time when it is connected for the test. This is really an advantage, and is effected by the bar from R to J at the key. On looking at this key in either figure, 29 or 30, we see that on depressing S, and thus joining the battery lead to the key, the point T is separated from J, and the centre piece R remains fixed, so that the cable can be joined either to the battery or earth separately. But in Fig. 23, &c., the cable is disconnected from earth until the key piece A is depressed. The pieces M and N may be two ebonite pillars, somewhat similar to those mentioned in No. 1 as being fixed on the large commutator; their leads, and most of the others joining the several keys, &c., may pass through holes and lie under the surface of the table. One pole of the battery is always to earth through J; one condenser pole has the same earth connection, the other condenser pole by being joined to F can be put to earth by depressing G, or connected to the galvanometer by putting down H; this pole is also joined directly to the trough through N, and the galvanometer connects with earth by the lead through B to J. This arrangement is as neat, and at the same time as complete, as we could wish in a case where an earth connection is used for the test.

We commence, as before, by testing the insulation of the trough, and may first follow the same course by shifting the lead from M to N (Fig. 30), and depressing first H, and then instantly putting down S, thus getting an immediate discharge from the trough, and afterwards repeating the operation, but depressing S for a minute before touching down H, and compare the deflections. But instead of removing the lead from M, we may judge if the insulation is sufficient by connecting the galvanometer to the condenser and trough, through depressing H; only on repeating this two or three times we ought to have little or no deflection as a final result. This at first sight appears to be assuming rather than testing the insulation of the trough, or, it may not be clear to the learner how we expect this mode of observation to afford any certain information; although if there be a charge it will be made evident. Let us see, then, what the action is. We will first short-circuit the condenser by depressing G, and thus entirely discharge it, then releasing G, touch down H, and if a deflection results it will be owing to a remnant of charge in the trough, which should thus be discharged through the galvanometer to earth. If, now, on releasing H and again touching it down a much less deflection or none at all occurs, we conclude that the trough is quite discharged and also well insulated. If, on the contrary, an equal deflection followed the second touch down, or if on holding the key down a permanent deflection appeared, we must attribute it to the reception by the trough of a charge from some other source; this must be through communication with the earth. For the condenser was perfectly discharged at first, and the trough would have also been cleared at one contact. The consideration of the point is not a mere matter of curiosity or uncertainty either. Experience has shown the existence of the facts, and the joint test is in certain respects so peculiar that it is not safe to neglect any indications, even if they seem to be anomalous. We have already said that we believe this is not as definite or decisive as other tests—shall we say, also, not so well understood?

We will, however, now suppose the trough to be well insulated. Then, after short circuiting the condenser for a moment, we should touch down H and immediately afterwards S, and observe the deflection; H would then be released and S clamped down for, say, one minute. It is to be noted that H must be depressed before S, that the effect of the inductive charge on the galvanometer may be exactly coincident with the direct charge of the cable, that is, that the path may be open all through, as it were. At the end of the one minute H is to be touched down and released, and

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the deflection noted. The battery is still kept on, however, for another minute, when H is again touched down; the deflection now given must be much smaller (little or nothing) in comparison with that for the first minute, and if so, the battery key is released, while H is kept down for a moment, and the deflection for the inductive discharge should be in the opposite direction to that of the other three, but equal in amount to the first.

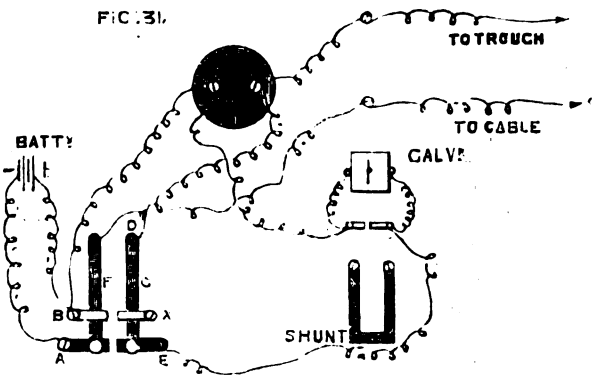
It sometimes happens that the deflection for the second minute is as large or larger than that of the first minute. Speaking generally, we should from this conclude that the joint was bad, from the fact of so much fresh leakage after being discharged a minute before; but it is not necessarily the case, and it is better to leave the battery key down for a third minute, and observe a third time, when the deflection may be satisfactory. This shows the peculiarity of the test, and seems to be contradictory; it is generally explained vaguely as being due to "inductive disturbance," but if the final result appears correct, it may be accepted without trying to account for it. If, however, the third minute shows no improvement the joint cannot be passed, but as we are just now assuming our test to be satisfactory, the consideration of this difficulty with others that may appear is postponed for the moment. The action during the course of the operation is easily understood by looking at the figure. The cable is charged whilst S is down, and the leakage from the joint passes to the condenser, whence the accumulation is discharged through the galvanometer to earth on depressing H. The details are all made plain by the preceding explanation of the connections.

We will next proceed to consider the operation with connections arranged without earth communication. The learner might have been in some degree prepared to understand this method at first sight if we had followed the principle in connection with the capacity test which is sometimes taken without earth. We purposely omitted this at the time, but may say briefly that the difference between using and not using earth is this:—Instead of putting one pole of the condenser to earth in order to charge it we bring one pole to communicate with one battery pole, and the other with the other pole; the battery, of course, has no earth in this case. Further to produce a deflection from the accumulation in the condenser, each of its poles communicates with either terminal of the galvanometer coil, this latter also having no earth. To answer the objection naturally occurring to the learner that a condenser cannot be charged unless one pole is to earth (as we impressed on him in No. VI. and VII.) we must explain as simply as possible how this comes about. The condition is a *sine quâ non* only when one pole of the battery is to earth, in which case the circuit is completed by means of the two earth connections. This circuit which exists in all cases of electrical action is said to commence at the + pole of the battery, and to be completed at the — pole. The action may be most conveniently explained by quoting some words from a book published some years ago, but now out of print, and whatever theory may be preferred we have here a view which suits our purpose better than any other*:—"Whenever electrical generation occurs there always exists, besides a source of generation, at which the normal electrical equilibrium is first disturbed, certain conditions which allow the positive and negative electricity to recombine, or else certain other conditions by which the electricity generated is accumulated on two surfaces separated by a medium through which it either cannot recombine, or only so less rapidly than the source can generate." The case of a good conducting body outside the battery, or a conductor which is uniform and unbroken throughout answers the first of these propositions, and that of a condenser whose two poles are connected directly to the battery poles represents the second, and, further, it is only necessary that there should be a means of recombination, whether the earth form part of the circuit or not, so that in charging a condenser with one pole to earth we have again an illustration of the first of the above two propositions.

In thus defining the action in an electrical circuit we wish to state distinctly that we use the explanation as the best mode of expressing what we cannot decisively pronounce upon.

We will now consider the plan of connections in Fig. 31. One key only is used, namely, a double-current split key. Its action is similar to that of the double-current key already illustrated, but there is no communication between the two

FIG. 31.

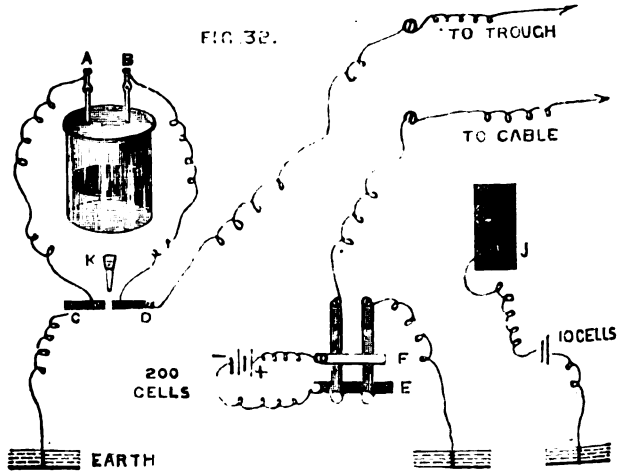


Joint Test; No Earth Connection.

opposite sides. The end contacts C and D lead to the condenser and cable respectively, the battery leads are joined to A and B, and the galvanometer to E. When F is depressed the bar is separated from B, and the cable is charged from A. The circuit may then be traced through the joint to the trough (or the water) and so to the condenser pole I. The other condenser pole H connects with the opposite battery pole by B. This replaces the earth arrangement in Fig. 30, where one condenser pole and one battery pole is put to earth. In a similar way one terminal of the galvanometer is connected directly to this pole of the condenser instead of to earth as in Fig. 30. The point X in the key is not used in this test. The course of proceeding is seen at a glance after the explanations already given. We first depress G on E, and instantly touch down F and mark the deflection (the inductive charge); then, releasing G, clamp down F and depress G again after three minutes if one leakage deflection only is required, or after one minute and two minutes if taking two separate deflections. Then, keeping down G, release F, and we have the inductive discharge. We have added a shunt in this figure, but it is not needed more in this than in the other arrangements; it may or may not be convenient to use it. It appears unnecessary to say any more at this point on this test as taken with the galvanometer; we have yet to illustrate the operation when using the electrometer.

In Fig. 32 we have suggested an arrangement for this pur-

FIG. 32.



Joint Test with Electrometer.

pose which shows the principle clearly enough, though the connections might be variously made. The action will be understood by referring to the remarks on the use of the electrometer in No. V. The rise or fall of potential in any electrically charged body is observed by connecting it to one pair of quadrants, the other pair being to earth. The insula-

* "Electrical Accumulation and Conduction," by F. C. Webb.

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tion of the trough is determined by noting the fall and the goodness of the joint by watching the rise (or rate of rising) of the potential in the quadrants. The dotted line in the figure represents a lead which may be connected temporarily or otherwise for testing the insulation of the trough. The key G H is for charging and discharging the cable. The test is taken as follows:—The plug K being inserted, the key J is depressed, and the pair of quadrants B is charged from the separate small battery of 10 cells along with the trough (or the water in it). On removing the plug a deflection results, representing the potential of the battery. If the trough were *perfectly* insulated this deflection would remain permanent as long as the battery key J is kept down, but any conductive communication of the trough with earth would cause an escape of part of the charge, and the potential will fall; the deflection will tend backwards towards zero. The insulation should be good enough to allow of only one or two divisions for this fall. If this is all right the plug is inserted and the key J released. We should have said that this trough test would generally be taken before putting the joint into the water. Removing the added trough lead, and again lifting the plug, the key G is now touched down, the cable is charged from the large battery, and an induced charge causes a deflection which may or may not be regarded. The plug is replaced and the battery key clamped down. The charge will leak at the joint according to its quality, and on removing the plug again the quadrants to which the trough is connected will acquire the potential of the water. The greater the leakage from the joint the higher will this potential be. The time for continuing the charge and the amount of deflection allowed will have been decided previously. If the discharge is to be observed, the key G will be released without reinserting the plug K, which is returned at the end of the test.

The joint test with the electrometer is considered more decisive than those with the galvanometer and condenser, but the latter are more generally employed. The analogy between the two modes of testing is this. When using the galvanometer the leakage from the joint accumulating in the condenser measures or represents the potential, since, the battery being kept on, the amount escaping is being continually replaced by it. With the electrometer we observe the potential *directly*, by comparing that acquired by one pair of quadrants with the earth or zero potential of the other pair.

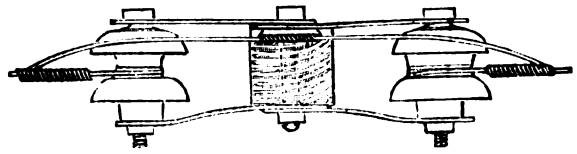
Before concluding these chapters on the joint test we must mention a few difficulties that may arise, and add a caution or two for the benefit of the learner. In the first place, the dimensions of the joint itself is a point worthy of attention. If it be too large (too thick) the consequences may be serious. Joints have been known to be squeezed on this account when passing through the sheathing machine, and in some places it has been the custom for the electrician to gauge every joint before testing, using a metal gauge through which it must fairly pass. The jointer should have previously done so with an exactly similar gauge; but, without wishing to insinuate anything against their correctness, we must hint that the jointer's gauge sometimes passes freely over a joint which the electrician finds too large for his own; he will do well to remember this. In the next place care should be taken that the trough should be perfectly clean and rubbed dry the last thing before commencing the test. For this may have been done some time before, but the atmosphere may be very damp, and the dust of the shop may cling to its surface and form minute chains for leakage to earth. In very damp weather, also, the leads should be wiped as dry as possible for the same reason; and in all weathers, damp or dry, the core for a few feet on either side of the joint must be well dried. It may further happen at times that a test shows by too large a deflection an apparent weakness of the joint. This may be the result of the cause just mentioned, very wet weather, for which allowance is permitted to be made, but if the matter appears in dry weather, it is well to go out into the shop and examine the arrangements of the trough, &c. Perhaps it may be found to have been placed on wet ground; it may be surrounded by water lying about. The boys employed in the core tanks are often very careless in this respect, and allow the hoses attached to the tanks to run over the ground and produce this evil result.

One more point is worth noting, and involves in its consideration a general caution for insuring, as far as possible, the correctness of all the arrangements. The jointers' box or office is generally above the floor, and the two ends of the coils to be united are passed up to the window-hatch. He has simply to join these two ends; other hands have the duty of selecting the proper ends, and, as a rule, a mistake scarcely ever occurs. But it has been the fact that a wrong coil has been selected, and its end joined out of its proper place. The two ends of one coil have even been jointed together owing to a mistake of this nature. We repeat, such errors are rare, but being possible, it is well for the electrician to be as active and thoughtful as he can in assuring himself that everything has been duly prepared.

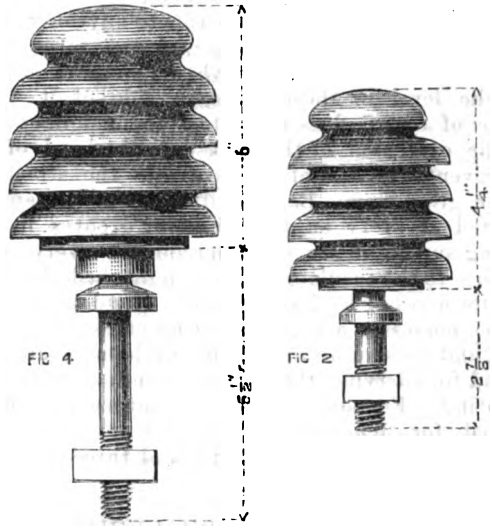
BENNETT'S INSULATORS.

Early in 1882 Mr. Alfred R. Bennett designed the two insulators illustrated herewith, his object being to improve the insulation of the lines erected for the National Telephone Company by Messrs. D. and G. Graham, of Glasgow. The wires taken over by the National from the late Bell and Edison Telephone Companies and others were seriously

FIG 1



deficient in this respect, so much so that overhearing between wire and wire was common, and in many cases was obviously due, not to induction, but to actual leakage. These wires were all constructed on the double-shackle system, which, indeed, before the introduction of the insulators now under consideration, was the one universally adopted for over-house telephone lines in this country. The double shackle is shown in Fig. 1. It consists of two porcelain cups having iron bolts right through them, which bolts are connected by four galvanised iron bands or straps, with a third bolt passing



through the support. The ends of the spans of wire are looped round each cup and joined by a soldered cross-connection. This arrangement has much mechanical merit, for it confines the effects of a break in a wire to the span upon which it occurs, and prevents the wire falling into the street in the event of a fracture of a porcelain cup. But its insulating properties are very inferior, for at each cup the current finds two roads to earth, which, everything else being equal, would, by the law of derived circuits, reduce the insulating efficiency of a single shackle cup to one-fourth of that of an upright insulator, and of the double-shackle to one-eighth. But in practice, especially in

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wet weather, the superiority of the upright, even if only a single-shed, is very much more marked, for the shackle has no inner cup, and no part of it can be kept even approximately dry. Probably a good double-shed upright insulates at least thirty times better than the double-shackle, its large effective dry surface being wholly in excess of the gain of eight times derived from the position of the wire at its summit and the existence of only one road to earth. A combination of the mechanical functions of the shackle and the insulating properties of the upright was, therefore, required, and this Mr. Bennett appears to have accomplished in his design. The insulators shown in Figs. 2, 3, 4, and 5 are used in precisely the same way as shackles, each span being terminated round the insulator, and joined through to the next by a soldered cross-connection. (Fig. 6.) When light wire, such as Nos. 16 to 20 phosphor-bronze, is employed, both spans are terminated round the topmost groove. With heavier wire it is better to terminate each span in different grooves, preferably the first and second from the top. When unusually long spans are unavoidable it is well to reduce leverage by

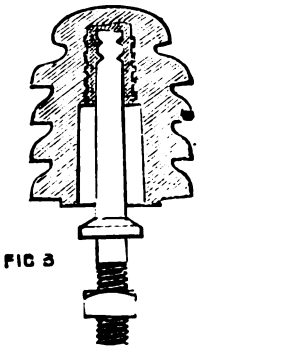

FIG 3

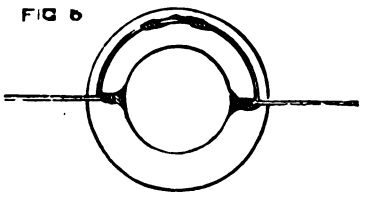

FIG 6

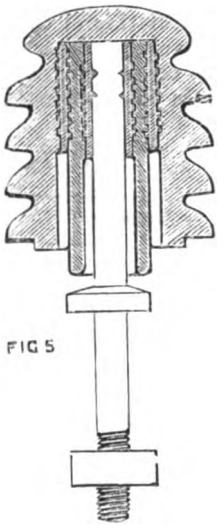

FIG 5

using the second and third or even the third and fourth grooves, the insulation under these circumstances, owing to the dry cup, still being far superior to anything obtainable from shackles. The terminating of the wires round the lower grooves is also advisable when a support chances to be below the level of those on each side of it. Thus the breakage of a span does not affect the neighbouring ones, while the extension of the stalk into the head of the insulator prevents the fall of the wire into the street when an insulator gives way. Besides allowing of the spans being terminated at every support the four grooves increase the insulating surface materially, and impart a very ornamental appearance to the insulator. The single-shed (Figs. 2 and 3) is used for wires of moderate length. The double-shed (Figs. 4 and 5) possesses a high insulating efficiency, is very substantial, and does admirably for long telephone and telegraph lines, and for carrying the heaviest conductors used in electric lighting. Economically, the insulators leave nothing to be desired, for each upright, with its bolt and nut, replaces two shackle-cups, four iron straps, and three bolts and nuts.

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

At the meeting of this society, held on Thursday evening, 8th inst., Mr. Willoughby Smith in the chair, two communications were read by the secretary relating to the magnetic storms and the earth current disturbances of last year. That from Mr. J. GRAVES, member, described the effect upon the cable between Valentia and Heart's Content on 17th and 18th November, 1882, the observations being taken at Valentia. The second paper was from Mr. E. O. WALKER, member, giving the results of observations on a magnetic storm in India, which occurred 12th September, 1882, and also some general remarks upon earth currents. In respect to the latter Mr. Walker stated that the observations made in India did not appear to confirm those taken in England, the electrical disturbances varying considerably in direction, and having apparently no connection with the moon's variation. Both papers were diagramatically illustrated, copies of which showing the curves of disturbances as indicated by galvanometer, being distributed among the members.

Mr. ALEX. J. S. ADAMS, associate, then read a paper on "Earth Currents, Sun Spots, and Electric Storms," being the third paper on this subject which Mr. Adams has contributed to this society. After referring to the several theories which had been held to account for the appearance of sun spots, and to the facts as to their apparent effects, Mr. Adams described particularly one phenomena connected with the spots observed during the month of November last. They were visible even to the unassisted eye, and were not fixed, but moved from east to west, contracting or enlarging as they neared the margin on either side of the sun's face. They disappeared over the eastern margin, and then reappeared, diminished in size, after an interval of about a fortnight on the western side. During a portion of the time these spots were visible great perturbations were observed in the electrical condition of the earth, a condition which he assumed to be normally constant, and, therefore, left the telegraphic systems in equilibrium, but which was liable occasionally to marked and even serious disturbance, so much so as to interfere and even interrupt all telegraphic signalling within the area over which the storm, as it was called, extended. That such a disturbance was likely to arise from every alteration in the condition of the heavenly bodies near enough to influence this earth Mr. Adams had already shown in former papers; and he had further suggested that those disturbances which are regular or periodic might be ascribed to the ever-changing position of the moon, and to the difference between its speed of revolution and that of the earth. That the cause of these disturbances is external to the earth, and not within it, Mr. Adams thought was evident from the circumstance that the effects were observable with the same regularity, and at the same moment of time, all over the world. He had carefully observed the effects on the telegraph lines between London and Leicester, and London and Leeds, during the great magnetic storm of last November, and of the curves of disturbances on the 17th of that month he now submitted diagrams. The sun spots were at that time conspicuous, and it was impossible to avoid the inference that the two phenomena had some connection. It was noticable, however, that the disturbance in the electrical condition of the earth did not conform to the passage of the sun spots—that is to say, the earth currents did not last during the whole period, but only for one portion of it. It occurred to him that this might be explained by assuming that the sun's atmosphere interfered with the electrical influence exerted by the sun's body upon the earth, and that possibly the dark spots were breaks or rifts in the sun's atmosphere. If that were so, then the earth would be subject to the direct action of the sun, only when the spots, or gaps in the sun's atmosphere, were centred on the earth. The sun's revolution occupies twenty-five days, and consequently the spots were visible to us for half that period, say twelve days. If, then, his theory were correct, the magnetic storm would be highest on the sixth day after the appearance of the spots: that is to say, when their position centred on the earth; and this is what really occurred. On the 12th November the spots made their appearance; there was then no electrical disturbance observable, and none till the 17th, when it burst upon us and lasted with varying intensity for three days, disappearing altogether on the 21st, the sun spots, however, continuing in sight for five days longer. The inference he had drawn from these observations was confirmed by the reappearance of the spots, diminished in intensity, on the 9th of the following month, earth currents becoming troublesome six days after, as on the former occasion, that is to say midway between the first appearance of the spots and their disappearance. If his conjectures proved to be correct, then it would in future be possible for astronomers to predict when we may expect these magnetic storms or earth current disturbances.

Professor ADAMS, while complimenting the society on the interesting paper to which they had listened, feared that the facts were not yet so complete as to justify us in basing any theory upon them. He considered it very remarkable, however, that by comparing the magnetic disturbances recorded in 1880 at many places remote from each other they proved to be simultaneous, and on comparing the curves he had found them to coincide generally with great exactitude; for example, the curves described by the magnetic deflection at two points so far separated as China and Lisbon were absolutely identical. It was worth noticing that during the prevalence of sun spots the earth receives less heat than usual from the sun, and connecting this fact with Professor Hughes's new theory of magnetism, it is possible that we may soon be able to frame a consistent theory in explanation of the known phenomena.

A discussion followed in which several members took part.

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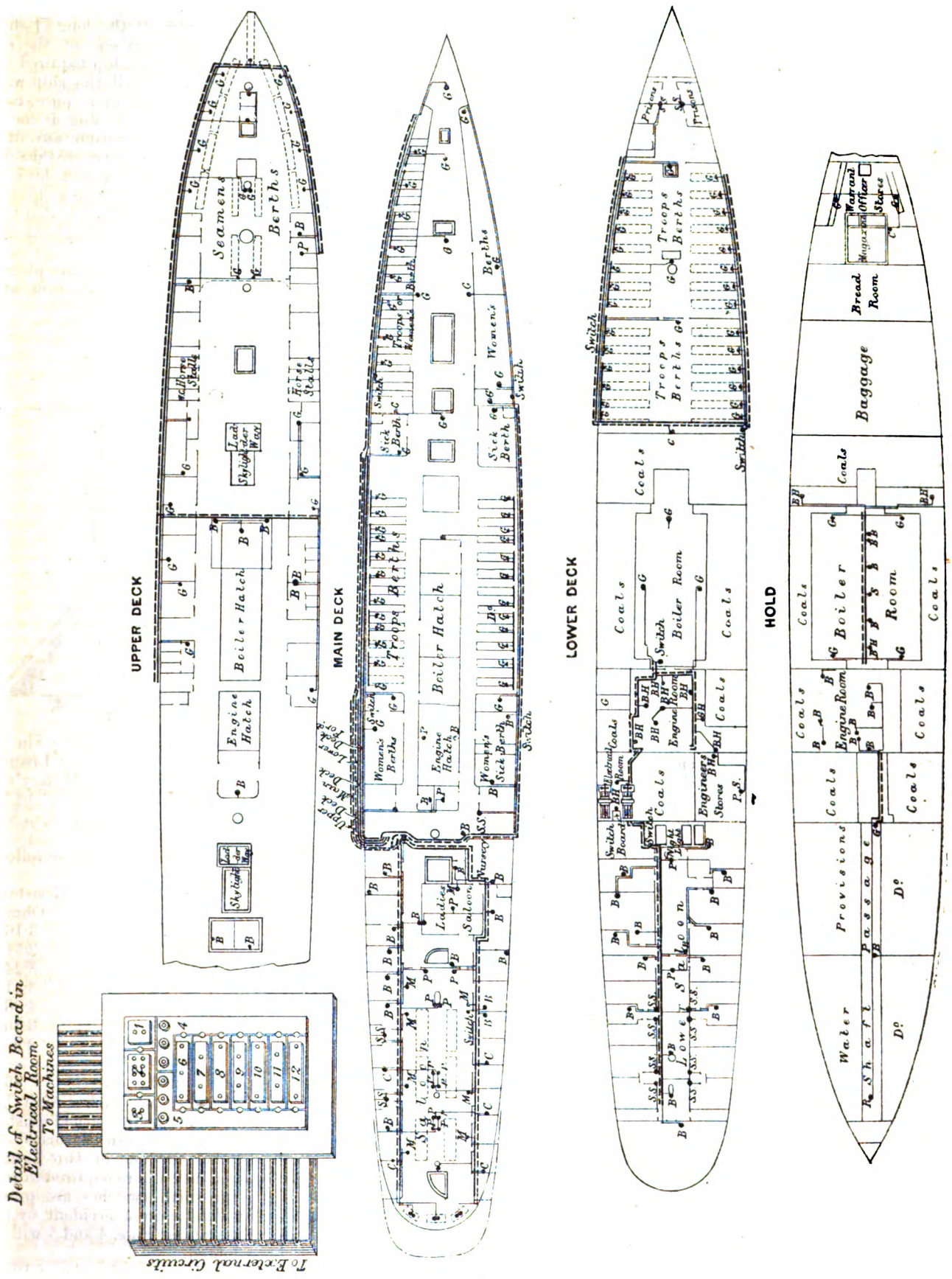
THE LIGHTING OF H.M.S. "HIMALAYA."

Since the days when the war ships of the Danes caused consternation among the inhabitants of the English coast, when such rulers as Alfred built vessels to meet the marauders upon the sea, England has reigned supreme as a maritime nation. We are, in fact, descendants of maritime races, and are proud of our ships. The more enlightened among the shipowners are always anxious to test new inventions that tend in any way to ameliorate the conditions of life on board ship. Hence the great companies owning passenger vessels tried the electric light almost as soon as the inventors themselves stated it to be at all practicable. We have often dwelt upon the adaptability of the



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incandescent light for ships' use, and were glad to record the lead of private companies being followed by the Government. A short time since, *vide The Electrician*, Vol. X., No. 5, we briefly described the work of the Swan United Company carried out on board one of the Indian troopships —the "Himalaya." It does not come within our province to describe these magnificent vessels. They have often been described in the technical papers, but we trust soon to chronicle the extensive use of the electric light in all such ships. Readers of voyages and travels—and who has not read them—have often read of the sufferings from heat in trips through the Red Sea, and in other tropical seas, and not only those who suffer from sea sickness but almost every traveller will agree that, although it may be impossible to get rid of the heat, they are glad to find it possible to do away with the nauseous smell of the oil lamps, and to have in their place the purer, and at all events scentless, incandescent lamp.

The installation of the electric light on board the "Himalaya" has been carried out by the Swan Company, whose tender was accepted on October 23, the work being finished for the official trials on December 13th. The time was not long, and when it is considered that, owing to "speed trials" and other work, considerable delays arose, credit must be given for having thus early completed the installation. We are informed that every facility was given by the dockyard authorities at Devonport for pushing forward the work.

The lamps used are of two kinds—viz., 20 candle-power lamps, and 10 candle-power lamps. There are 171 of the former and 78 of the latter, giving a total of 249 lights. The 20 candle-power lamp, to give its normal light, requires a current of about 1·24 ampere, with an E.M.F. of 54 volts. These lamps are all arranged in multiple arc, but the 10 candle-power lamps are placed two in series and in multiple arc, two of the latter being equivalent to one of the former. The arrangements were carried out by Mr. J. F. Albright, of the Swan Company. The lamps have been distributed throughout the ship in the manner shown in the illustration on page 321. The lamps are arranged on seven circuits, all of which are controlled from a main switch-board, placed in the electrical room. A detailed sketch of the switch-board is shown at the upper left hand corner of the illustration. On reference to the sketch it will be seen that the lower part consists of seven long brass plates. Upon these are the names of the various parts of the ship, but in the sketch they are referred to by numbers 6, 7, 8, &c., for clearness. Thus:—

6 indicates plate on which name Upper Deck appears.
7 indicates plate on which name Forward Main Deck appears.
8 indicates plate on which name Aft Starboard Main Deck appears
9 indicates plate on which name Aft Port Main Deck appears.
10 indicates plate on which name Forward Lower Deck appears.
11 indicates plate on which name Aft Lower Deck appears.
12 indicates plate on which name Engine Room appears.
Nos. 1 and 3 indicate plate for machine returns.
No. 2 indicates plate for return leads.
No. 4 indicates plate for port machine.
No. 5 indicates plate for starboard machine.

The brass plates 6, 7, 8, &c., are divided from each other, and also from the two long ⌐-shaped brass plates, which, together with seven plates just mentioned, make up a complete rectangle. The lower part of the switch is separated by a division running right across the "board," from the upper or return part. The lower part forms the lead section, and it is, as will be seen, on this part that all the seven circuits are made or broken.

The six cables represented by six full lines at the top are fixed in the six terminals shown at the top of the "lead" section of the "board," three being for each machine. The four cables shown by four dotted lines, two for each machine, are fixed in the terminals on the two plates marked machine returns.

The seven cables shown in seven full lines go to the terminals on the seven plates named with the parts of the ship, the seven cables shown in the seven dotted lines go to the terminals or plate marked "return leads" which should be called "external returns."

To use the port machine insert the plug between the right hand "machine return" plate and the "return leads" plate, and then insert another plug between the long ⌐-shaped plate, marked "port machine," and any one of the seven named plates according to the part of the ship required to be lighted. When the seven plugs are in all the ship will be lighted, and if both machines are working at once, to use the starboard machine insert the second plug at the left-hand machine return plate, and then transfer any of the seven plugs from the port machine to the starboard machine.

The whole of the brass work is solidly screwed down to a strong backing of vulcanised fibre; this is set in a stout teak frame, supported by two wrought-iron brackets bolted to the bulkhead, arranged to set the board at an angle of about 30deg. with the bulkhead.

The grooved teak casing in which the cables are placed in the electrical room is brought up to and finished off at the switch-board.

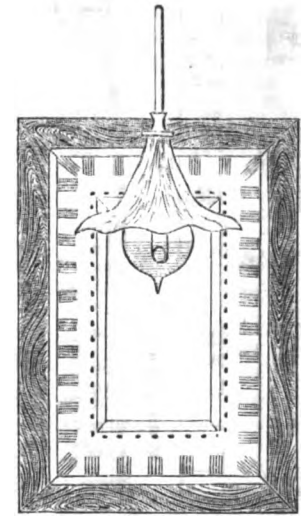

FIG. 1.

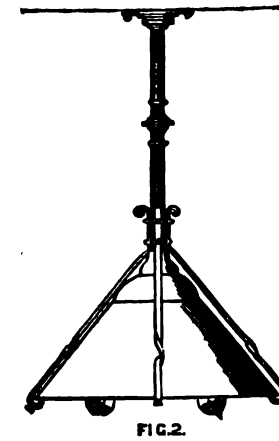

FIG. 2.

The over-all size of the brasses is about 13in. by 8in.; the switch was made by Messrs. J. J. Marr and Co., of Liverpool.

Throughout the ship in laying the wires Mr. Massey's rule of "leads to the left or lowest and returns to the right" has been observed as far as possible, it only having been necessary to break the rule once for a few yards.

As regards the resistance of various circuits, the following figures are roughly approximate:—

Circuits.	No. of Lamps = 20 C.-P.		Resistance Ohms.
Upper Deck	31	.....	3·16
Main Deck Forward	38	.....	2·51
Main Saloon Starboard	26	.....	3·24
Main Saloon Port	26	.....	3·41
Lower Deck Forward	23	.....	4·06
Lower Saloon	26	.....	3·48
Engine Room	40	.....	2·9
Combined Circuits	210	.....	·45

In addition to the main switch-board each circuit has a switch, so that, with the exception of lamps burned constantly day and night, the lamps of that circuit can be turned on or off, and further small switches for one or two lights are placed in all the cabins, and, in fact, where required to govern the lamps in detail. All the small switches are provided with lead cut outs, so that danger from accident by heavy currents is avoided. Our illustrations Figs. 4 and 5 will show the forms of the switches adopted.

The main leads are of Siemens Brothers' make of 19 wires of No. 16 B.W.G., heavily insulated with tape and india rubber. The branch wires are of a single No. 16 B.W.G. wire, with an equally high class insulation, specially made for ship work by the (Silvertown) Gutta Percha and India

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Rubber Company. The leads and returns are laid in grooved wood casing, ½in. apart, the greatest care having been taken throughout the ship to avoid any possibility of short circuits

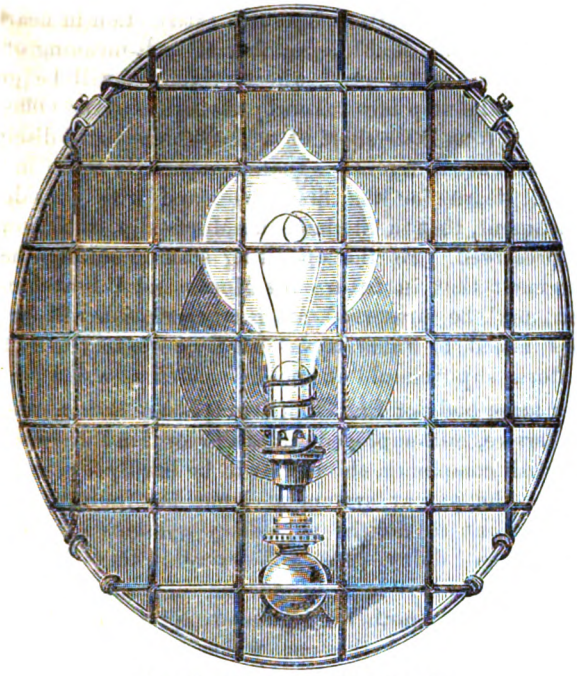

Fig. 3.—Lamp with Wire Guard.

or of metallic contact with the framework of the ship, lead cut outs being inserted at the junctions of all branch wires.

The fittings are of several kinds, of some of which we give

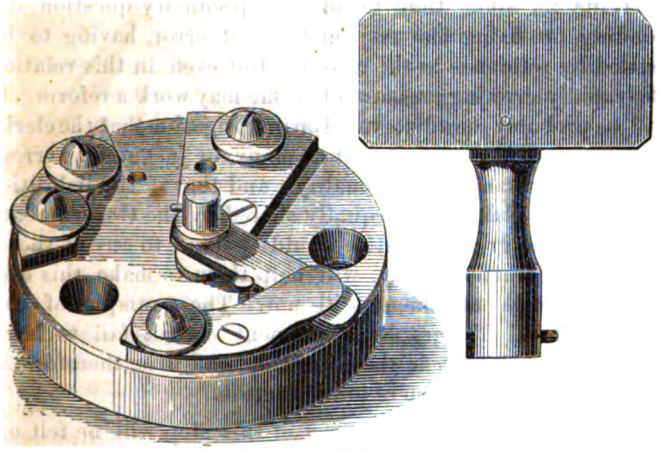

Fig. 4.—Switch.

illustrations; the greater part of them were supplied by Messrs. Faraday and Sons. Ornamental mirrors (Fig. 1) are used on the panels of the main saloon, the centre of

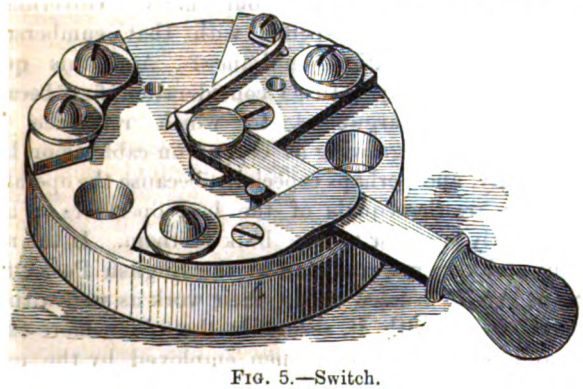

Fig. 5.—Switch.

which is lighted by plated brackets, while over the card tables aft are fixed three handsome double-light plated pendants (Fig. 2). The ordinary ship's bulkhead lanterns when possible have been adapted to suit the new lamps, and on all the troop decks or in exposed places a reflector with wire guard front (Fig. 3), specially designed for this ship, and suggested by Mr. Farquarhson, of the Admiralty, has been used. The remainder of the fittings are ordinary ship's brackets.

We understand that at the official inspection before alluded to the Admiralty experts expressed themselves well pleased with the result, both as to workmanship and illumination obtained. In reference to the latter, however, a few additions were suggested, which were promptly carried out, and subsequent experience has shown that in regard to the distribution and amount of light there is nothing further to be desired.

The electric room, as will be seen from the plan, is reached through the engine room, but is not a part of it, a portion of the coal bunkers having been given up for the room. The space provided, about 19ft. 2in. × 10ft. 6in. is ample for the duplicate set of engines and machines required under the contract.

The machines are of the Siemens alternate current type, with specially large exciters running at the same speed as the machine. The speed is about 640 revolutions per minute, when the maximum light is required, though in practice 610 revolutions are generally found sufficient even with all the lights in circuit.

The engines run continuously, are of the well-known Brotherhood type, with three cylinders, and are coupled direct to the machines. Engines and machine are both on one cast-iron bed-plate, which is placed on an 8in. teak bed, the whole being firmly bolted to the framework of the ship.

There are two separate services of steam pipes, one from the main boilers, and one from the auxiliary boiler, the exhaust steam being turned into the main condenser.

THE ACTION OF THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have watched with great interest the discussion going on in your journal for the last few weeks on the above subject, and I must say I am inclined to think Mr. Smillie is right in regard to the microphonic action of a Blake transmitter being due to the variation of the resistance of carbon under pressure, though at the same time I think that it is also partly due to the making of a better contact between the platinum stud and carbon button, due to the platinum point burying itself in the carbon button, and thereby causing an increase in the current owing to the resistance of the circuit being diminished.

With regard to "Loose Contact's" letter in your issue of 27th ult., he says Mr. Smillie, in his second letter, abandons the compression theory. Now, on reading that, I turned up *The Electrician* containing the letter referred to, and read it over, and I must say I fail to see how "Loose Contact" comes to that conclusion. He denies saying that a brass button would speak as well as a carbon one. Well, he certainly did not put it in plain English, but I am at a loss to know what other construction could be put on the sentence reading thus:—"Then let him blow upon and tickle his diaphragm as before, and inform you, Mr. Editor, whether he thinks the diminished resistance which he will observe *is still due to the compression of the carbon button.*"

He also says that the fact of Mr. Smillie getting the brass button to speak proves his case to the hilt. It certainly would have done so if it had spoken well, but Mr. Smillie says he got the brass button to speak, and that was all. It certainly looks very like as if the defect in the speaking was due to the fact that the brass is practically incompressible.

With regard to Mr. Smillie not getting the same galvanometric action as "Loose Contact" predicted, I think he is rather premature in condemning Mr. Smillie's galvanometer until he knows whether Mr. Smillie used the same one for his experiments with the carbon and brass buttons, as, if he did, and it was not a good one, it would be equally bad for both tests.—Yours, &c.,

John Hill.

455, St. Vincent-street, Glasgow.

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THE ELECTRICIAN.

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TO CORRESPONDENTS.

C. N. R...ll.—At present there is a lull in electric light work, but no doubt, as soon as the provisional orders, licenses, &c., are settled, there will be a strong demand for competent men. Why not write to some of the companies?

J. M...e.—We shall make a point of calling on you at the Palace, and seeing all you have to show us, at the earliest opportunity.

X.—Our space is far too small for the demands we have upon it. Business men, shareholders, &c., ask for full reports of all meetings. It is, they say, important there should be no break in the continuity of the reports. Practical men tell us we give too much science, that formulæ are no doubt good in their way, but indigestible to the ordinary reader—while the scientific thinker wants more pure science, and so on. On the whole, however, our friends are very lenient. Still, we must hesitate before giving a list of a column or half a column such as you desire. The attention of writers shall be directed to your remarks.

C. B. C.—Write to Mr. A. J. Frost, the librarian, who will give you all the information you require.

THE MORSE SLIP.

The announcement we made in our last issue that the postal telegraph authorities of this country had discontinued the practice of preserving Morse slip will be received with surprise in many quarters, but with satisfaction in nearly all. There are still, no doubt, a number of well-meaning officers, both at home and abroad, whose prejudices will be greatly shocked at the step now taken by the British Post Office, and will regard it as little short of a deathblow to all discipline. Others who are differently situated, especially those in America, will learn for the first time, and with considerable astonishment, that in England the Morse slip, until now, has been preserved. To the operating staff generally the announcement that in future the Morse and Wheatstone slip "need not" be preserved after transcription will be good tidings indeed, to which it was hardly necessary to add that said Morse slip "should at once be treated as waste paper."

To a large body of English telegraphists, not in the Post Office service, but employed on cables or land lines worked by English companies, the news will be hardly less welcome; for what the parent system at home has found it possible and expedient to do, the subsidiary systems cannot long refrain from doing. At all events, they have now one argument the less in favour of adhering to the old practice. Another argument, probably the most effectual of all, and the one which has probably proved conclusive for the Inland authorities, namely, the pressure of traffic, will in due time convince the rest of the telegraphic world as well. On international lines, that is to say, lines worked direct between nation and nation, the preservation of slips, either Morse, Wheatstone, or Hughes, may continue for some time to come—a pecuniary question, depending on fixing the responsibility of error, having to be settled by reference to the record. But even in this relation the rapidly-growing pressure of traffic may work a reform. It will be probably soon discovered on investigation that the clerks of one nationality commit just as many, or just as few, errors as do those of another nationality; and that if the liabilities in respect to claims were equally shared by the Governments concerned no great injustice would be done to any of them. Increase of traffic, we say, will help them to make this discovery, though argument will not. The example of the British Postal Telegraph Department cannot fail to have some effect, however, in that direction, and it is, therefore, a subject of more than mere local interest.

For similar reasons the effect of this step will be felt on lines that are not international in the sense above alluded to—that is to say, on lines worked at both ends by the servants of one administration. The question will arise why should we any longer preserve slip, Morse or Syphon, or any kind whatsoever, when our native Government has seen its way to dispense with that cumbersome and in every way vexatious nuisance? And this question will be less easily refused consideration, first because the same practical argument to which reference has already been made is growing as cogent on cable as on land lines; secondly, and perhaps especially, because the operators on cable lines are the equals of the best operators on land lines, and vastly superior to the bulk of them. If the miscellaneous and very unequal staff of the English Post Office Telegraphs can be trusted to do their work as well without the slip check as with it, assuredly the older, more experienced, and generally superior men employed by the cable companies may be so trusted.

Of course we are aware there is another consideration in the background besides the good faith or the skill of the

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operator. The class of messages dealt with by the last-named *employés* is far more costly, and the consequences of error or carelessness are relatively more serious than those of any inland system of telegraphs. As a fact, however, the inland system does deal largely with this class of messages in its terminal stages, and the announcement we are discussing makes no exception in favour of foreign, cypher, or cable telegrams. The slips of all alike are to be treated at once as waste paper. Moreover, it is rather illogical and contrary to experience to suppose that difficult and expensive telegrams will be signalled with less conscientious exactness than are the cheap and easy messages of a local system. The exact contrary is the fact, and it is not in the least affected by the preservation or non-preservation of the slip. For many years after the introduction of telegraphy the charge for an inland telegram was as high as that for a cablegram is now, and the instruments were non-recording. Possibly the proportion of errors diminished on the substitution of recording apparatus—possibly, though not certainly; and in any case the improvement, if any, was due more to the new instrument than to the terror its record was supposed to have inspired.

It comes to this, in fact, that the slip has been preserved simply to humour administrative martinets. Errors can be traced to the miscreants who commit them, and punishment awarded. This is enough for the disciplinarian, and he is happy. True, they can as easily be traced, and almost as certainly, without any slip at all, but punishment is not so confidently inflicted, nor so often; therefore the slip has survived until now, and will, we suppose, survive in some places for a long while yet to come in order that fines may be inflicted. And this, notwithstanding the obvious injustice and impolicy of preserving the slip for mere detective and tell-tale purposes—injustice, because it inflicts the heaviest penalties on the clerks who do most work; impolicy, because its tendency is to decrease the speed of working, and the zeal of the working staff.

THE TELEPHONE CASE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It may interest your readers, apart from the detailed report which you furnish elsewhere, to draw attention to some of the salient points in this remarkable case.

The description in the evidence of Sir W. Thomson of the final step in Bell's invention is of no less popular than scientific interest. In the earlier form of Bell's instrument—which spoke at Philadelphia, but was dumb before the British Association at Glasgow in 1876—the reproduction of sound depended upon the vibrations of a thin plate or tongue of metal attached at a single point to the box containing the magnet. Every one at the time, including Sir W. Thomson, supposed that on the freedom of vibration of this plate or tongue the whole action depended. Mr. Bell's final success was achieved by using a substantial metal plate, firmly set down on the top of the box; and the surprise which this created, in 1876, amongst scientific men seems only equalled by the difficulty, in 1883, in conceiving that any one would attempt to use the Philadelphia or Glasgow instrument without holding down the lid. No less remarkable were the experiments of Professor Silvanus Thompson before the Court of Appeal, showing how, in 1883, not only the Glasgow form of Bell's instrument, but an instrument constructed from the much earlier description and drawings of Reis, could be made to speak articulately and clearly. It was no wonder that after these experiments the Court required a long and powerful argument from the side of the respondents to enable them to appreciate the position of the scientific world in 1876, before the marvellous stride in the science of acoustics which followed upon the achievement of the articulate-speaking telephone.

More interesting to the lawyer is the treatment—and, perhaps, extension—by the judges of the Court of Appeal of the doctrine conventionally described as the *benevolent* or *benignant* doctrine of construction or interpretation. The specification claimed, according to the more obvious reading of it, the production of undulating currents. In the most general sense of the expression this claim was not new; but if read as a claim to the production of undulatory currents so as to reproduce articulate speech in the manner described, it was new and good. The Court held the claim *capable* of this latter interpretation, and gave the inventor the benefit, so as to make the patent valid.

The decision upon this point is all the more weighty, as the language of the Lords Justices is carefully guarded against allowing the claim in a specification to be made a mere trap to the public. The judgment of Lord Justice Bowen is particularly clear and explicit. He described the decision as being merely the application of the ordinary rules of construction to a very special subject matter; but he suggests a principle which may prove a new point of departure in Patent Law, namely, the *interpretation from the point of view of the honest inventor*.

If it had been avowed that there is one rule of construction for the specification of the honest inventor and another for that of the patent-monger, who, on the minimum of inventive achievement, seeks to appropriate the maximum out of the field of invention, the doctrine, if morally wholesome, might have seemed legally questionable. The importance of the lucid exposition of Lord Justice Bowen is to show that a principle tending in this direction within carefully guarded limits, is not less sound in law than desirable on grounds of utility. The legal construction of a document is simply its meaning as ascertainable from the point of view of the parties to it. To interpret a will, you have to look at the surrounding circumstances of the testator. To interpret a contract you must look at the surrounding circumstances of the parties, and ascertain the meaning of the language of the document from their common point of view. From this point of view it is ascertained, for instance, whether a trade usage is or is not to be introduced into the contract. Upon the same principle the grant of a patent as described in the specification is to be ascertained from the point of view of the inventor—not forgetting, of course, that he is addressing a public composed of persons having skill in the subject matter. And—what is the gist of the decision of the Court of Appeal—if, upon the evidence of the surrounding circumstances, it is shown that he is an honest inventor seeking to give the public the benefit of a new and useful machine, his claim, if *capable* of a construction that will make the grant good, is to be construed accordingly, although it is capable of another and even an easier construction which would make it bad.

What gives special importance to the decision upon this point is that it only restates and formulates what is essentially the judgment of the House of Lords in the British Dynamite Company *v.* Krebs (April 7, 1879), a decision briefly reported only in the weekly notes of cases in the *Law Journal*, and which does not seem at the time to have attracted the attention due to the importance of the doctrine involved in it.

There is one other point suggested and disposed of during the argument of the telephone case before the Court of Appeal, which it may be the more useful to note here, as it was not again referred to in the judgment. At one stage of the reply the well-nigh assured success of the respondent seemed for a moment imperilled by the suggestion, that *one* of the claims as read with the disclaimer was enlarged beyond the original claim. It was, however, pointed out by Lord Justice Lindley that, although the *particular* claim was enlarged, this enlarged claim was still within the scope of the original grant *as a whole*. And on the well-known principle that in considering the validity of the grant you must look at the whole of what is claimed, and not at the claims taken separately, this was clearly sufficient to support the patent as disclaimed.—Yours, &c., R. C.

Lincoln's Inn, Feb. 12, 1883.

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STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are alternative solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. RIMINGTON, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

11. This question is the same as No. 8 of the pass examination, where the answer will be found. (*Electrician*, Dec. 2.)

12. What is the principal of a photometer? What form of photometer is most suited for use with strong electric lights? About how much per cent. are English "standard candles" found to differ? Describe Vernon Harcourt's light standard. What is your experience of the relative penetrating power of gas and the electric light in a fog? Explain what you think is the cause of this result, and in what way you would propose to increase the penetrating power of the electric light.

Ans. The first two parts of this question were answered in No. 11 of the pass examination.

English standard candles are found to differ from about 3 to 4 per cent., that is to say, even in the same packet of candles one may be found to average about 118 grains of spermaceti per hour, while another may burn 121 or 122 grains in the same time. For very accurate working the candles are weighed at the beginning and at the end of the experiment.

Vernon Harcourt's standard, which is exceedingly exact and trustworthy, is an air gas flame 2½in. high, proceeding from a burner with a ¼in. orifice. The gas is burned at a definite rate, and consists of a definite mixture of air and the vapour of light petroleum.

In a yellow London fog the rays from gas have relatively a far greater power of penetration than those coming from an electric arc lamp; this is due to the fact that the gas contains far more red and yellow rays than the arc light, which, is on the other hand, far richer than the gas in the blue and violet rays.

The yellow colour of the fog absorbs a large quantity of the blue and violet rays, while it allows the red and yellow to pass with comparatively small loss.

The penetrating power of the electric light might be increased by mixing some substance with the carbon that would give the arc a more yellow tint.

The penetrating power of incandescent lamps in a fog is much the same as that of gas.

13. Describe in detail and give sketches of the instruments employed for measuring large currents and large electromotive forces—first, when the currents and electromotive forces are continuous; second, when they are rapidly reversed. Compare the relative advantages and disadvantages of the various forms of instruments.

Ans. The instruments principally employed for measuring large currents are Ayrton and Perry's ammeter and Siemens's dynamometer, the latter of which is applicable for either continuous or alternating currents. Both of these were described in answer to Question 12 of the pass examination. For measuring large electromotive forces Ayrton and Perry's voltmeter and Siemens's voltmeter are, perhaps, the best known and most generally employed. The former is in external form the same as the ammeter; it is, however, wound with a high resistance, and in the commutator form is employed with the coils in multiple arc for low E.M.F.'s and for calibrating, and in series for high E.M.F.'s, when it is ten times less sensitive. Its terminals are simply connected to the two points between which the difference of potential is required.

The principal advantages of Ayrton and Perry's instruments are that they are perfectly dead beat, the pointer marking the division that gives the current or E.M.F. at the moment of observation, and that they will work in any position; whilst in Siemens's instruments the pointer at the top of the dial has to be altered until the torsion of the spring exactly balances the attraction and repulsion of the coils. This is exceedingly inconvenient in measuring a rapidly-fluctuating current or E.M.F. Another disadvantage is that they must be perfectly level.

The advantage of Siemens's instruments over Ayrton and Perry's is that they can be employed with alternating currents, because the directions of the currents in the two coils are relatively the same to one another at whichever terminal of the instrument the current enters. Ayrton and Perry's, on the other hand, show in which direction a continuous current is flowing, being so wound that the needle points to the terminal at the highest potential.

14. How is the current flowing through any circuit, and the electromotive force maintained between its ends, connected with the horse-power expended in the circuit? Describe an electric-power meter for measuring from one observation the horse-power electrically expended in a circuit. Give a full account, with sketches, of the experiments you would make to measure the number of candles produced per horse-power expended in an electric lamp. Give the results of any experiments that have been made, showing how this efficiency of a lamp varies with the work electrically done in it.

Ans. The product of the current flowing in an electric circuit, and the E.M.F. maintained between its ends, divided by the constant 746, is equal to the horse-power electrically expended in that circuit, either in doing mechanical work or in producing heat.

$$\frac{C\,E}{746} = W \text{ in horse-power,}$$

as

$$C = \frac{E}{R},$$

$$\frac{C\,E}{746} = \frac{E^2}{746\,R} = \frac{C^2 R}{746} = W \text{ in horse-power.}$$

Messrs. Ayrton and Perry have invented an instrument called the "electric-power meter" for measuring at one observation the horse-power expended electrically in any circuit. This instrument consists of a coil of very fine wire, having a high resistance, wound on a long thin bobbin, and capable of moving about an axis parallel to the length of the bobbin. This coil is capable of moving inside another fixed coil of very thick wire, or of ten thick wires arranged so that they are able to be joined up either in multiple arc or in series by means of a commutator similar to that employed in the ammeter. The moving coil is either hung from a bifilar suspension, or arranged with a wheel and pinion and two fine spiral springs, one or both of which latter can be employed, and so two very different grades of sensibility given to the instrument. The rack and pinion arrangement magnifies the deflection of the fine coil as shown by the pointer ten times.

The thick coil is placed in the main circuit, and the fine coil is employed as a shunt on that part of the circuit in which the horse-power is desired to be measured. The thick coil thus measures the main current, while the fine coil measures the difference of potential between the two points, to which it is connected. The deflection, therefore, of the latter measures the product of the current and the E.M.F. or C.E.

By turning the commutator so as to place the ten thick wires in series the sensibility of the intrument is increased ten times, either for the means of calibration or to measure the power expended in a small part of the circuit, such as in one incandescent lamp. To measure the candle-power produced per horse-power electrically expended in an electric lamp, the current passing through the lamp is found by means of an ammeter or other instrument for measuring current, while the difference of potentials at the terminals of the lamp is measured by a voltmeter, or both observations may be obtained at once by use of the instrument just described. If, however, the ammeter and voltmeter are employed, the current in amperes is multiplied by the number of volts indicated by the voltmeter, and the product divided by 746. Simultaneously with the above operations the candle-power of the lamp is obtained by means of a photometer. Then if a be the number of candles indicated, and b the horse-power electrically absorbed in the lamp, $\frac{a}{b}$ is the number of candles obtained per horse-power expended in the lamp.

ERRATUM.—In the answer to Question 3 of pass examination the word field-magnets occurs instead of armature, through an inadvertent slip in writing.

ELECTRIC LIGHTING TO THE RESCUE.—Owing to the fearful floods at Cincinnati, U.S.A., the gas supply has been cut off for some days. As Mrs. Langtry was in this city a few days since to fulfil an engagement at the theatre there, it was found necessary to call in the aid of electric lights for the illumination of the theatre for the occasion.

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CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture III. (*continued*).—*The Dynamo as a Motor.*

(CONTINUED FROM PAGE 307.)

Jacobi's law concerning the maximum work of an electric motor supplied with currents from a source of given electromotive force is the following:—The mechanical work given out by a motor is a maximum when the motor is geared to run at such a speed that the current is reduced to half the strength that it would have if the motor was stopped. This, of course, implies that the counter-electromotive force of the motor is equal to half the electromotive force furnished by the battery or generator. Now, under these circumstances, only half the energy furnished by the external source is utilised, the other half being wasted in heating the circuit. If Jacobi's law were indeed the law of efficiency, no motor, however perfect in itself, could convert more than 50 per cent. of the electric energy supplied to it into actual work. Now Siemens showed,† some years ago, that a dynamo can be, in practice, so used as to give out more than 50 per cent. of the energy of the current. It can, in fact, work more efficiently if it be not expected to do its work so quickly. Dr. Siemens, to whom we owe the honour of having first shown us the true physical signification of the mathematical expressions which, until then, had been regarded as mere abstractions, has, in fact proved that if the motor be arranged so as to do its work at less than the maximum rate, by being geared so as to do much less work per revolution, but yet so as to run at a higher speed, it will be more efficient—that is to say, though it does less work, there will also be still less electric energy expended, and the ratio of the useful work done to the energy expended, will be nearer unity than before.

The algebraic reason is as follows:—If E be the electromotive force of the generator when the motor is at rest, and c be the current which flows at any time, the electric energy, W, expended in unit time, will be (as expressed in watts) given by the equation.

$$W = Ec = E\frac{(E-e)}{R} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now, when the motor is running, part of this electric energy is being spent in doing work, and the remainder is wasting itself in heating the wires of the circuit. We have already used the symbol w for the useful work (per second) done by the motor. All the energy which is not thus utilised is wasted in heating the resistances. Let the symbol H represent this heat. Its mechanical value will be H J, where J stands for Joule's equivalent. Taen clearly we shall have

$$W = w + H J.$$

But, by Joule's law, the heat-waste of the current, whose strength is c running through resistance R, is expressed by the equation

$$H J = c^2 R.$$

Substituting this value above, we get

$$W = w + c^2 R, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

which we may also write

$$w = W - c^2 R.$$

But by equation (1) $W = Ec$, whence

$$w = Ec - c^2 R, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and, writing for c its value, $\frac{E-c}{R}$, we get:

$$w = \frac{\left(E-e\right)\left(E-\left\{E-e\right\}\right)}{R},$$

$$\text{or } w = e\frac{E-e}{R} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

Comparing equation (5) with equation (1), we get the following:—

$$\frac{w}{W} = \frac{e\,(E-e)}{E\,(E-e)}$$

or, finally—

$$\frac{w}{W} = \frac{e}{E}.$$

This is, in fact, the mathematical law of efficiency, so long misunderstood until Siemens showed its significance. We may appropriately call it the law of Siemens. Here the ratio $\frac{w}{W}$ is the measure of the efficiency of the motor, and the equation shows that we may make this efficiency as nearly equal to unity as we please, by letting the motor run so fast that e is very nearly equal to E; which is the true law of efficiency of a perfect motor supplied with electric energy, under the condition of constant external electromotive force.

Now go back to equation (3), which is:—

$$w = Ec - c^2 R.$$

In order to find what value of c will give us the maximum value for w (which is the work done by the motor in unit time) we must take the differential coefficient and equate it to zero.

$$\frac{dw}{dc} = E - 2cR = o,$$

whence we have

$$c = \tfrac{1}{2}\frac{E}{R}.$$

But, by Ohm's law, $\frac{E}{R}$ is the value of the current when the motor stands still. So we see at once that, to get maximum work per second out of our motor, the motor must run at such a speed as to bring down the current to half the value which it would have if the motor were at rest. In fact, we here prove the law of Jacobi for the maximum rate of doing work. But here since—

$$c = \frac{E-e}{R} = \tfrac{1}{2}\frac{E}{R},$$

it follows that

$$E - e = \tfrac{1}{2}E;$$

or

$$\frac{e}{E} = \tfrac{1}{2},$$

whence it follows also that

$$\frac{w}{W} = \tfrac{1}{2}.$$

That is to say, the efficiency is but 50 per cent. when the motor does its work at the maximum rate.*

Now, though several graphic constructions have been suggested to convey these facts to the eye, none have hitherto been, to my mind, quite satisfactory. I have, therefore, worked out a new construction, which enables me, in one diagram, to exhibit graphically both Jacobi's law of maximum rate of working, and Siemens's law of efficiency.

Let the vertical line A B (Fig. 34) represent the electromotive force E of the electric supply. On A B construct a square, A B C D, of which let the diagonal B D be drawn. Now measure out from the point B along the line B A the counter-electromotive force e of the motor. The length of this quantity will increase as the velocity of the motor increases. Let e attain the value B F. Let us inquire what the actual current will be, and

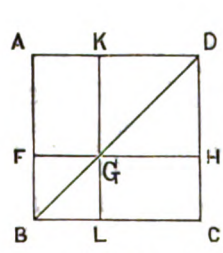

FIG. 34.

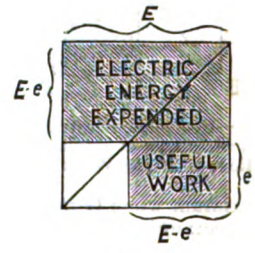

FIG. 35.

* Reprinted from the *Journal of the Society of Arts.*

† The matter was also very well and clearly put by Prof. W. E. Ayrton, in his lecture on "Electric Transmission of Power," before the British Association in Sheffield, in 1870.

* It may be worth while to recall a precisely parallel case that occurs in calculating the currents from a voltaic battery. Every one is familiar with the rule for grouping a battery which consists of a given number of cells, that they will yield a maximum current through a given external resistance when so grouped that the internal resistance of the battery shall, as nearly as possible, equal the external resistance. But this rule, which is true for maximum current (and, therefore, for maximum rate of using up the zincs of one's battery) is not the case of greatest economy. For if external and internal resistance are equal, half the energy of the current will be wasted in heat in the cells, and half only will be available in the external circuit. If we want to get the greatest economy, we should group our cells so as to have an internal resistance much less than the external. We shall not get so strong a current, it is true; and we shall use up our zincs more slowly; but a far greater proportion of the energy will be expended usefully, and a far less proportion will be wasted in heating the battery cells. The maximum economy will, of course, be got by making the external resistance infinitely great as compared with the internal resistance. Then all the energy of the current will be utilised in the external circuit, and none wasted in the battery. But it would take an infinitely long time to get through a finite amount of work in this extreme. The same kind of reasoning is strictly applicable to dynamos used as generators, the resistance of the rotating part of the circuit being the counterpart to the internal resistance of the battery cells. For good economy the resistance of the armature should be very low as compared with that of the external circuit. Mr. Edison seems to have been struck by this point, as his endeavours to reduce the resistance of his armature coils to the utmost limit of possibility show.

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what the energy of it; also what the work done by the motor is. First complete the construction as follows:—Through F draw F G H, parallel to B C, and through G draw K G L, parallel to A B. Then the actual electromotive force at work in the machine, and producing the current, is $E - e$, which may be represented by any one of the lines A F, K G, G H, or L C. Now the electric energy expended per second is—

$$\frac{E(E-e)}{R}$$

and the work done by the motor is—

$$\frac{e(E-e)}{R}$$

Since R is a constant, the relative values of the two may be written respectively—

$$E(E-e)$$

and

$$e(E-e).$$

Now

$$\text{area A F H D} = E(E-e),$$

and

$$\text{area G L C H} = e\,(E-e).$$

The ratio of these two areas on the diagram is the efficiency of the motor.

Let us turn to Fig. 35, in which these areas are shaded. This figure represents a case where the motor is too heavily loaded, and can turn only very slowly, so that the counter electromotive force e is very small compared with E. Here the area, which represents the energy expended, is very large; while that which represents useful work realised in the motor is very small. The efficiency is obviously very low. Two-thirds or more of the energy is being wasted in heat.

Next, let us turn our attention to the smaller area, G L C H. Obviously, the value of this area will depend upon the position of the point F; for if F is very near B, the area will be very small. If F moves upward, the area, G C L H, will have a value that increases up to a certain point, and then diminishes again; for if F be taken very near A (that is, if e be very nearly equal to E), the area, G L C H, will become again a very narrow strip. Of all the possible cases, the area of this rectangle will

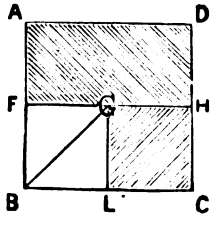

FIG. 36.—Geometric Illustrations of Jacobi's Law of Maximum Rate of Doing Work.

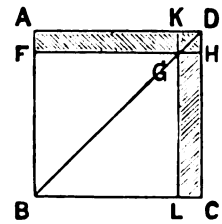

FIG. 37.—Geometric Illustration of Siemens's Law of Efficiency.

be a maximum when G is midway between B and D; for of all possible rectangles that can be inscribed in the triangle, B C D, that rectange which is a true square will have the greatest value, as drawn in Fig. 36. But if G is midway between B and D, the rectangle, G L C H, will be exactly half the area of the upper rectangle, A F H D; which is, in fact, Jacobi's law of the efficiency of a motor doing its work at its greatest possible rate. Also F will be halfway between B and A, which signifies that $e = \frac{1}{2}E$.

Again, consider these two rectangles when the point G moves indefinitely near to D (Fig. 37). We know, from Euclid's "Second Book," familiar from our school-days, that the rectangle, G L C H, is equal to the rectangle, A F G K. The area (square), K G H D, which is the excess of A F H D, over A F G K, must, therefore, represent that part of the electric energy which is wasted in heating the resistance of the motor and circuit. In Fig. 35, this corner square, which stands for the heat waste, was enormous. In Fig. 36 it was exactly half the energy. In Fig. 37 it is only about one-eighth. Clearly, we may make the heat-waste as small as we please, if only we will take the point F very near to A. The efficiency will be a maximum when the heat-waste is a minimum. The ratio of the areas, G L C H and A F H D, which represents the efficiency, can only become equal to unity when the square, K G H D, becomes indefinitely small; that is, when the motor runs so fast that its counter electromotive force, e, differs from E by an indefinitely small quantity only. Further, it is clear that if our diagram is to represent any given efficiency—for example, an efficiency of 90 per cent., then the point, G, must be taken so that the area G L C H = 9-10ths of the area A F H D; or G must be 9-10ths of the whole distance along B D. This involves that e shall be equal to 9-10ths of E, or that the motor shall run so fast as to reduce the current to 1-10th of what it would be if the motor were standing still. Thus we verify, geometrically, Siemens's law of efficiency.*

In all the preceding discussion I have supposed that the motor is to be worked with a supply of current furnished at a fixed electromotive force. It is not only convenient, but I believe wise, to make such a condition the basis of the argument, because this is, probably, the condition under which electric power will, in the not very distant future, be distributed over large areas. It would be absurd, in the present stage of electro-technical science, to deal with such a question as the construction and use of motors, without taking into account the practical conditions under which they will be used. It is true that the condition of having a constant fixed electromotive force is not the only condition of supply; for, as we have seen in preceding lectures, a generator or system of generators may be worked so as to yield a constant current. And it would be quite possible to formulate a set of rules for the efficiency and maximum duty of motors under this condition. But this method of distributing electric power is far less likely to be of importance in the near future than the system of distribution with constant electromotive force; though for the case of transmission of power to an isolated station the case becomes of importance. One simple problem connected with this case is worthy of mention. Suppose that one is desirous of working a motor so as to do work at the rate of a specified number of horse-power, and that the wire available to bring the current cannot safely stand more than a certain current, without being in danger of becoming heated unduly. It might be desirable to know what electromotive force such a motor ought to be capable of giving back, and what electromotive force must be applied at the transmitting end of the wire. Let N stand for the number of horse-power to be transmitted, and c for the maximum strength of current that the wire will stand (expressed in amperes). Then, by the known rule for the work of a current, since

$$\frac{ec}{746} = N,$$

$$e = \frac{746\,N}{c}$$

gives the condition as to what electromotive force the machine must be capable of giving when run at the speed it is eventually to run at as a motor. Moreover, the primary electromotive force, E, must be such that

$$\frac{E-e}{\Sigma R} = c,$$

where ΣR is the sum of all the resistances in the circuit. Whence

$$E = e + c\Sigma R,$$

which is the required condition.

Another problem in the application of motors to transmission of power, which vitally affects their construction, is the determination of the relation of the heat-waste to the electromotive force at which the current is supplied to the motor.

If, as before, ΣR stands for the sum of all the resistances in the circuit, then, by Joule's law, the heat waste is (in mechanical measure)

$$HJ = C^2\Sigma R.$$

And, since $c = \frac{E-e}{\Sigma R}$, we may write the heat-waste as

$$HJ = \frac{(E-e)^2}{\Sigma R}.$$

Now suppose that, without changing the resistances of the circuit, we can increase E, and also increase e, while keeping $E - e$ the same as before, it is clear that the heat loss will be precisely the same as before. But how about the work done? Let the two new values be respectively $\acute{E}$ and $\acute{e}$. Then the electric energy expended is

$$\acute{W} = \frac{\acute{E}(\acute{E}-\acute{e})}{\Sigma R},$$

and the useful work done is—

$$\acute{w} = \frac{\acute{e}(\acute{E}-\acute{e})}{\Sigma R}.$$

That is to say, with the no greater loss in heating, more energy

* We have all along supposed the motor to be a "perfect" one, that is to say, one which gave out as available mechanical work all the electric work it took from the supply of energy of the current. No motor does this, because of friction, &c. But it is easy to adapt the construction to the case. Suppose when working the motor as a generator, so as to give an electromotive force, e, we found that it was capable of converting 80 per cent. of mechanical energy into electrical energy, then we may put down the efficiency of the motor, *per se*, under the given conditions at 80 per cent. All we have then to do is to take an area 8-10ths of the size of the area G L C H (or cut off 1-5th of G L C H), and this will really represent the available mechanical work of the motor.

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is transmitted, and more work done. Also the efficiency is greater, for

$$\frac{w}{W} = \frac{e}{E},$$

and this ratio is more nearly equal to unity than $\frac{e}{E}$, because both E and e have received an increment arithmetically equal. Clearly, then, it is an economy to work at high electromotive force. The importance of this matter, first pointed out by Siemens, and later by Marcel Deprez, cannot be over-rated. But how shall we obtain this higher electromotive force? One very simple expedient is that of driving both the generator and motor at higher speeds. Another way is to wind the armatures of both machines with many coils of wire having many turns. This expedient has, however, the effect of putting great resistances into the circuit. This circumstance may, nevertheless, be no great drawback, if there is already a great resistance in the circuit—as, for example, the resistance of many miles of wire through which the power is to be transmitted, in this case, doubling the electromotive force will not double the resistance. Even in the case where the line resistance is insignificant, an economy is effected by raising the electromotive force. For, as may be deduced from the equations, when E—e is kept constant, the effect of doubling the electromotive force is to double the efficiency, when the resistance of the line is very small as compared with that of the machines, and to quadruple it when the resistance of the line is very great as compared with that of the machines. It is, in fact, worth while to put up with the extra resistance, which we cannot avoid, if we try to secure high electromotive force by the use of coils of fine wire of many turns. It is true that the useful effect falls off, *cæteris paribus*, as the resistance increases; but this is much more than counterbalanced by the fact that the useful effect increases in proportion to the square of the electromotive force.

In the recent attempt of M. Marcel Deprez to realise these conditions, in the transmission of power from Miesbach to Munich, through a double line of telegraph wire, over a distance of thirty-four miles, very high electromotive forces were actually employed. The machines were two ordinary Gramme dynamos, similar to one another, but their usual low resistance coils had been replaced by coils of very fine wire. The resistance of each machine was consequently 470 ohms, whilst that of the line was 950 ohms.* The velocity of the generator was 2,100 revolutions per minute; that of the motor, 1,400. The difference of potential at the terminals of the generator was 2,400 volts; at that of the motor, 1,600 volts. According to Professor von Beetz, the President of the Munich Exhibition, where the trial was made, the mechanical efficiency was found to be 32 per cent. M. Deprez has given the rule that the efficiency $\frac{w}{W}$ is obtained, in the case where two identical machines are employed, by comparing the two velocities at the two stations. Or

$$\frac{w}{W} = \frac{n}{N}$$

where N is the speed of the generator, n that of the motor. There is, however, the objection to this formula, that the electromotive forces are not proportional to the speeds, unless the magnetic fields of the two machines are also equally intense, and the current running through each machine the same. This is not the case if there is leakage along the line. Moreover, when there are resistances in the line, the ratio of the two electromotive forces of the machines is not the same as the ratio of the two differences of potentials, as measured between the terminals of the machines.

I now turn back from these somewhat abstract questions to consider, by the light we have derived already, some points in the design and construction of motors. We shall find that many of the rules suggested in my former lecture are applicable also to the case of motors, and supply answers to many of the questions that naturally arise.

In the first place, shall we build motors large, or shall we build numbers of small ones? In my first lecture I proved that, in the dynamo used as a generator, the capacity for doing work increased as the fifth power of the linear dimensions; that by doubling a dynamo in length, breadth, and thickness, we had a machine weighing eight times as much, costing less than eight times as much, but capable of doing thirty-two times the work, and that with a great gain in economy in working. The same thing is true of motors. Suppose instead of building eight small motors, we build one large one, of doubled dimensions. It will not cost so much as the eight, will get though four times as much work as the eight put together, and will be more economical in working. I assume here, of course, that the large machine can be placed under equally advantageous conditions of supply.

This is by no means the only one of the points in the theory of the dynamo which can be applied to practice in the cases in which the dynamo is used as a motor. I will give another example.

In the prospect of an immediate field of usefulness opening out for motors, so soon as we have such a thing as regular town supplies of electric currents laid on, it is most important that motors should be designed, not simply to work with the constant electromotive force supplied at the electric mains, but designed also to work at uniform speeds. It is highly important, for example, in driving a lathe, and indeed many kinds of machinery, that the speed should be regular, and that the motor should not "run away" as soon as the stress of the cutting tool is removed. Now, in my second lecture, I spent some time explaining the methods by which M. Marcel Deprez and Professor Perry had solved a converse problem to this, namely, that of getting a dynamo to feed a circuit with currents, at a constant electromotive force, when driven with a uniform speed. The solution to that problem we saw consisted in using certain combinations for the field magnets, which gave an initial magnetic field, independently of the actual current furnished by the dynamo itself. Now, it is not hard to see that this problem may be applied conversely, and that motors may be built with a combination of arrangements for their field-magnets, such that when supplied with currents at a certain constant electromotive force, their speed shall be constant, whatever the work or no work which they may be doing. The one difficulty in the problem—and this is a mere matter for experiment and calculation—is to find the critical number of volts of electromotive force at which this will hold good. It is, in fact, the converse to the operation of finding the critical velocity at which one of Deprez's or of Perry's combination dynamos must be driven, in order that it may give a constant electromotive force. M. Marcel Deprez has, himself, constructed motors upon this plan. Some three years ago I saw one of Deprez's motors, which ran at a perfectly uniform speed, quite irrespective of the work it was doing. Whether it was lifting a load of five kilogrammes from the ground, or was letting this load run down to the ground, or ran without any load at all, the speed was the same. At the Paris Exposition Electrique of 1881 a large number of Deprez's motors were shown, running at uniform speed and driving various machines, lathes, sewing machines, &c.

Amongst others who have aimed at producing a motor to work at uniform speed are Professors Ayrton and Perry. Professor Ayrton informs me that one of these motors, weighing only 350 pounds, will give an effective power equal to 8 horse-power, and that "without any mechanical governor; without anything, in fact, in the nature of a moving governor, it always goes at the same speed, whatever work it has to do." Certain little legal matters connected with the protection of this invention have debarred Professor Ayrton from informing me more fully of the new machine, which, if it fulfils the promise of its inventors, will be a great step forward in the mechanical application of electricity. But I can hazard a guess that the arrangement for obtaining uniform speed is dependent on the prior condition that the motor be supplied, either with a constant electromotive force, or with a constant current of a certain "critical" value; and that the solution of the problem is virtually one of the cases of combination, the counterpart of which, as applied to generators, I discussed last week.

(TO BE CONTINUED.)

* These figures, and those which follow, are given on the authority of the President of the Munich Exhibition, Professor von Beetz. It is but fair to add that M. Deprez is not satisfied of their accuracy.

STORAGE BATTERIES.

[The *New York Sunday Herald* for January 28 gives the report of an interview with Mr. Edison. We this week give that part of the report dealing with storage batteries, and hope to give that dealing with lighting in our next issue. We have left out some of the more strongly worded sentences, and also the names, inasmuch as these do not affect the argument.—ED. *E.*]

"The storage battery is, in my opinion, a catch-penny, a sensation, a mechanism for swindling by stocking companies. The storage battery is one of those peculiar things which appeal to the imagination, and no more perfect thing could be desired by stock swindlers than that very self-same thing. In 1879 I took up that question, and devised a system of placing storage batteries in houses connected to mains and charging them in the day time, to be discharged in the evening and night to run incandescent lamps. I had the thing patented in 1879 (I forget the

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date of the patent), but there is nothing in it. I rung all the changes on it. My plates were prepared like Planté's. The method of preparing them for charging is more tedious, but it is better than that of Faure, after preparation. You know the first storage battery was sent from France by Faure to Sir William Thomson, who was at first astounded by it. He was asked to endorse it, consented, and took a retainer; but, on investigation, he became convinced that there was nothing in it, and returned the retainer to the French company. The fact is, the more he investigated the more he found out the fallacy of the whole business. On account of what Labouchere calls a swindle this secondary battery has been used by the arc companies in England. One company alone, on the strength of an accumulator and an incandescent lamp copied from mine by ———, floated subsidiary companies whose aggregate capital was over 30,000,000 dollars, and immense sums were paid by these companies to the parent company for rights. This was the great ——— electric light bubble, in which millions were lost, and caused the now celebrated article of Labouchere. One of the leading spirits in the bubble is in this country at the present time attempting to do the same; but Carlyle's saying about 30,000,000 fools probably did not apply to foreign countries. "Scientifically, storage is all right, but, commercially, as absolute a failure as one can imagine. You can store it and hold it, but it is gradually lost, and will all go in time. Its efficiency, after a certain number of charges have been sustained, begins to diminish, and its capacity and efficiency both diminish after a certain time in use, necessitating an increased number of batteries to maintain a constant output. Owing to corrosion of the sustaining plates of the battery, the effect of local action, and other causes, too many to enumerate, the yearly depreciation of the battery is not less than 30 per cent. of its first cost if used daily. The facts are that there are two or three companies that have been organising subsidiary arc light companies throughout the country for some time past. In this arrangement the parent company made money by selling machinery, &c., to the working companies, but the latter are not making money, and have nearly ceased giving new orders. Now these parent companies, finding the call for machinery slacking, have come in with their secondary batteries. They now make this statement, which is the cleverest thing I ever heard of. Here, gentlemen, you have a large investment in machinery, &c., for furnishing light, but are not making any money out of it. Now, we have something by which you can utilise your machinery. You can work day and night, and can do more work. You can utilise your present plant in the daytime, and the electricity thus made in the daytime for incandescent lighting, and in the night have your plant for arc lighting direct. That sounds good and fair, does it not? The board of directors discuss the offer, and think it a good thing. Then they conclude to go into it. You know," said Mr. Edison, with something of contempt in his tone, "what the wisdom of the average board of directors amounts to. I will tell you where the fallacy in this arrangement lies. It consists in the fact that the cost of batteries to store this extra electricity that could be produced in the daytime would be twice as much as that of the station that produced it; so that, if the company has already 100,000dols. invested, and agree to utilise their machinery in the daytime by the addition of storage batteries, they will find that to carry out their desire it will cost them 200,000dols. for the batteries. I will guarantee that not one board of directors in a hundred will see it, and the parent company will not tell them of it until after they have purchased. It seems to be natural with boards of directors that if there be a wrong way to do a thing they will surely do it that way. Well, they have purchased the storage batteries, of course, at a cost of 200,000dols. On that investment, at the end of the first year, they have a depreciation of 30 per cent. To save themselves they will have to earn interest on their investment. They must earn enough to meet the extra depreciation on their plant running through the day, and will have to spend double the amount in coal to obtain the same output from the batteries, for the reason that they interpose between the source of energy and the light, a thing in which there is a loss both in charging and discharging, and a loss in standing, and that loss increases as the battery gets older, after a certain maximum is reached."

"What is the maximum of a storage battery?"

"It is about 50 per cent. You get the maximum of current when you utilise the full capacity of the battery, the same as in a steam engine, where, if steam is admitted for the full stroke, 50 per cent. of the steam or power is wasted, but you obtain the maximum power from the engine; but this is also the minimum of economy. Hence, to get the proper economy, engine builders only take one-third to one-fourth of the maximum power from their engines, but this adds to the investment, which is compensensated for by the saving in economy, which more than pays interest on increased investment. When they say that 90 per cent. is obtained from the battery they tell you what is scientifically true. They say they get 10 lights of 16 candles each per horse-power of current from a battery. Now that is true, and it is not true. If you get a horse-power of current from a battery it will give you 10 lights of 16 candles; but to get that you have to net all losses through the battery, through the wires, through the dynamo, and all that. They start off with a horse-power indicated in the engine. A certain amount of this is taken to move the engine and dynamo, and a certain amount is lost in the dynamo to convert power into electricity, because no machine is perfect; a certain amount must be lost on the wire connecting the station with the secondary battery; another amount is lost in charging the battery, due to its resistance and imperfection as a mechanism; another amount is lost during the interim between charging and use; another portion will be lost in discharging the battery through the lamps, and still another amount will be lost in the wire connecting the battery to the lamp. So that your horse-power will dwindle down until it will give you only about three lamps; whereas, if you worked direct you would probably get six lamps."

"You are hard on the battery folks."

"The reason I am down on these people is because I have a legitimate thing, and there is a loss of public confidence in it through their operations. We have never yet asked the public for money. Now, I don't want the people swindled, for I want our company to make money out of electric lighting in a legitimate way, by giving value for what is received, and, if it sells rights, to first prove to the purchasers their value by results, obtained in actual practice upon a large commercial scale, as is now being done, and the exposure of such things would make it much easier and better for me to advance my system on its true merits. The same swindle which it is designed to perpetrate upon the people of this country has already been carried out in England, and as a result people there have lost all confidence in electric lighting. The same people are here. We have entered suits against them in England, France, and other countries, and will sue them here. But these people know well that it will take some time to get a suit decided, and by that time they will have 'permitted the public to invest heavily.'"

"Then you consider storage batteries wholly impracticable. Is there no hope for their doing good, legitimate work?"

"None whatever. Except in a very limited number of cases, storage of gas could be made analogous to storage of electricity. One of the principal outlays of a gas company is for pipes. The average diameter of their mains is five or six inches. But, under pressure greater than they now force the gas through their mains, an inch pipe would answer under the storage principle of having a small gasometer in every house. The difference saved to the company by this arrangement would be about 15dols. for pipes from house to house, 20 to 30 feet apart. But the gasometer would cost a great deal more in each house than the 25ft. of pipe buried in the street. Besides, gasometers might not be just the thing in the hands of the public; there might be explosions; some of them might not have the room. The gasometer would require some little mechanism to reduce the pressure down to a limit where it could be burnt. Now, these little mechanisms are uncertain. The general intelligence of the public, when applied to mechanism, is also uncertain; and this has probably prevented gas engineers from introducing a system of local storage. The Electric Arc Company, which is seeking to introduce a system of storage, follow out the above idea exactly. Instead of using large conductors and low pressure electricity, as I do, they propose to save on the investment by using small conductors and high pressure electricity; and, to make this kind of electricity available, they reduce its pressure by means of a storage battery in the same way as high pressure gas in a small main could be stored in a gasometer and its pressure reduced to make it available. In the first place, the high pressure current is very dangerous to life. The depreciation on storage batteries alone, in a system of general distribution, would pay the interest on the extra copper sufficient to dispense with their use; and, second, if these small wires, carrying high pressure currents, were to be placed underground, as all systems must be to be financially permanent in large cities, the extra cost of the insulation necessary to prevent the leakage of the currents of so powerful a pressure would more than pay for the extra copper used in a system which carry low pressure currents and do not require so expensive nor so great an amount of insulation. The cost of our mains is about 15dols. from house to house. These mains are two feet underground, where the intellectual portion of the public cannot reach it to improve it, while with storage batteries, from 75dols. to 200dols. worth of batteries would be placed in each house to save about 9dols. in copper and interpose an uncertain device in which 50 per cent. of the article to be sold is lost." Mr. Edison here paused a moment, held down his head, and, quickly raising it again, said, in his quaint way, "Just as

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soon as a man gets working on the secondary battery it brings out his latent capacity for lying."

"But suppose power was cheap, such as a water power, would it not pay to store electricity even at a great sacrifice of energy?"

"In utilising water power, even where the cost of water is, say nearly nothing, there is still the cost of plant for storing to be considered, and interest and depreciation added. Where is the use of this outlay when, in nearly every case, by connecting the dynamo direct with the turbine you can get the same result far more cheaply? But you will remember that water power is not so cheap after all. It is only occasionally you can run across a water power that has a surplus in every month in the year beyond the wants of those who utilise it. These storage men will tell you that lamps burn better fed from batteries than from the source of power direct. This is not so. They are very brilliant when they start, but more battery must be put on from time to time, or they will soon go down. If you have a battery that will run ten lights, and wish to run them until 10 o'clock p.m., you must have other batteries to reinforce it, or the lamps will diminish in candle-power before the expiration of the time it is rated for. Then, after turning off the lights, the batteries will lose about one-fifth of the charge remaining in them before being recharged. There is a natural law working against the storage battery, and that is that finely divided lead decomposes water. It is stated that when Sir William Thomson had his attention called to this fact he threw up the sponge. All metals are fuel. When oxidised they are ashes, and it takes energy to put them back again into a metallic form, when it is again fuel. Mr. Brush may say he has a secret compound. It is nothing more than a salt of lead. They use lead, and their battery is nothing more than a Faure battery, plain and simple. They say they cannot furnish these batteries for six months. There are shops in this city that could turn out 6,000 of their cells within three weeks."

THE TELEPHONE CASE.

JUDGMENT.

Last week we gave the judgment of the Master of the Rolls in the case of the United Telephone Company *v.* Harrison, Cox-Walker, and Company, which was an appeal on the part of the defendants against the decision of Mr. Justice Fry given in May last. This week we give the judgment of Lord Justice Lindley. We had hoped to have given that of Lord Justice Bowen as well, but the pressure on our space compels us to hold it over until next week.

Lord Justice Lindley, in giving judgment, said: In this case, which has taken a long time, and is of very considerable importance, I think it will be most convenient, so far as my own observations are concerned, to begin with Bell's invention, to see what it was. Having done that, to deal with the objections raised to this patent. And Bell's invention, as I understand, so far as it relates to telephony, which is all we are concerned in, is of this kind. He discovered certain methods of receiving and transmitting and reconverting the sounds produced in the human voice, and he described his method of doing this in what has been called the fourth and fifth plans of his specification. In the fourth plan he described an electro-magnet of metal plate, fixed in the manner pointed out in that plan to a figure connected with it. In this plan there was a battery current along the wire, which was essential; it was also essential there should be continuous undulatory currents. In the fifth plan, there are two modifications—one was of a permanent magnet with an electro-magnet in four pieces, and a piece of metal placed before it. In the second variety there is an electro-magnet with a separate battery, and there was a separate screw to this. What was done, as I understand the *modus operandi* of this instrument, was this—first of all, it had in transmitting the human voice created certain vibrations in that metal plate. These vibrations excited the magnet in front of which the plate was fixed. The excitation of that magnet produced a current in the coil which passed along the wire, and had a receiving end, and *vice versâ*—that is to say, the current was received by an induction coil—the magnet affected the plate, and the plate affected the magnet. His real discovery—I am not now criticising the description of it, or the language of any particular portion of it—his real discovery was this:—First of all, he discovered the importance of continuous undulatory electrical currents as distinguished from pulsatory. There was one very important part of this discovery, and that was the importance of one particular set of currents. The next thing he discovered was the best way of producing, transmitting, receiving, and reconverting these continuous undulatory currents so as to render the human voice audible. That was by using a metal plate, as described in the plans. Then there was a third one, which is important. He discovered the fact that the same instrument would act as a transmitter and receiver. You have in that the essence of this discovery. It appears to me that that discovery is described with sufficient clearness in the specification, and that the claims, when you look at them fairly, amount to a claim for the discovery in a wide sense. Taking it as our starting point, let us see whether it can be said with anything like accuracy that that was an old invention which had been anticipated. Let us look back at Reis's patent. I have read the whole of the evidence more than once, and as I understand it people have now discovered how there could be got out of Reis's instrument something which, if known then, might have had the appearance of anticipation. It appears from some portions of the evidence that Reis understood his instrument. There are indications of his knowing more about it than anybody else did. But the main feature of Reis's apparatus, as known in this country in 1876, was that it was a receiver which acted as a transmitter. I am quite aware that by speaking low and taking care you can get out of it effects which were never dreamt of before; but looking at the description, whether you take the German or the English text, it looks plain, that, as understood in 1876, this invention of Bell's was in immense advance upon it. It appears to me that, inasmuch as the instrument described and patented by Bell is mechanical and otherwise different from Reis's, I cannot possibly say that Reis's was in anticipation of Bell's, although I quite admit now that we can, by improved methods or more delicate manipulation, get out of Reis's effects never dreamt of. With respect to the Glasgow receiver, the case stands in this way:—The first thing was to understand that receiver and see what it was. It was, in fact, an electric magnet, angular in shape, had an adjusting screw, which was surrounded by a metal case something like a drum, and had a lid upon it which was secured, and I think, according to the evidence, it must be taken that it was tilted up. Upon the whole, the evidence is clear and strong that it was tilted up. It was made in Philadelphia, given to Sir William Thomson wrapped in a brown paper parcel, and when it was open it was tilted up, and in that shape Sir William Thomson began to try to use it. We know, in point of fact, it failed—why, I do not know: perhaps he had not sufficient time to attend to it. The attempts made by Sir William Thomson with this instrument before the meeting of the British Association had not been successful. At the meeting of the British Association this thing was produced, was placed upon a table, and was spoken of, examined, and seen by those who cared to see it. It was not then linked to or joined to any transmitter at all. The transmitter and receiver were not connected, and all that was said in substance was that in America Sir William Thomson said he had heard proceed from a thing like that the human voice. If we look at this Glasgow thing, and at the thing described by Bell in this specification and patented, it is impossible to say that they are in all respects and precisely the same—of course, identity is out of the question. There are differences which may be important or unimportant; but what I mean is that there are differences which are plain enough. For instance, they are not so much alike as two daisies—they are different things, differently constructed, and whether they are the same in effect is quite another matter; but I can affirm truly that the thing described and patented by Bell is not in all respects similar to the Glasgow thing. I attach immense importance to that, because if the thing described by Bell, and patented by him, were precisely similar to the Glasgow thing it would place matters in a very different position. But there were differences capable of observation and description. What do people know what information was given, what disclosure was made by the production of this Glasgow thing? There was, it appears to me, abundant evidence to show that any competent person could have made one like that, having seen it; but when he got it, what was it then? It was, as it appears to me, a useless thing, and nobody knew how to use it; and not being the same thing, but being different from the Glasgow thing, it seems extremely difficult to see how the Glasgow thing can be regarded as an anticipation of the patent. It is curious and instructive to observe what can be got out of this Glasgow thing now. Now, it is said you can get out of this Glasgow thing all you can get out of the patent and transmitter—that is to say, so far as I know, we have not had proof that that Glasgow thing can act as a transmitter. I do not say it cannot, and I should have thought there would not have been much difficulty in proving that. Although that Glasgow thing has been made to speak more or less well in this court, all attempts to make it speak, even in the courts below, failed, until it fell into the hands of one of the most skilful men in England, but before having the knowledge of 1881 and 1882 to guide us it was practically useless. Can any one, using the knowledge which we now possess, and the knowledge we had in 1876—can it be said in any fair, rational sense that that Glasgow thing anticipated Bell's? I confess I cannot bring my mind to that at all. I do not think it is a sufficient answer to say that now we can get out of the Glasgow thing the effects we can get out of the Bell patent. There are various methods of investigating the problem. Did it enter the head of any man in England at that time that the Glasgow thing would transmit and receive? It may be that that was so, but was that shown to the public? Was it ascertainable by the public in 1876? I think the answer to that must be "No;" and the two things not being the same, but being different, it appears to me to say that the Glasgow thing of 1876 was an anticipation of Bell's patent is not borne out by the evidence. No other anticipation is suggested. Reis's was eventually suggested, and the Glasgow thing was strongly insisted upon as an anticipation, but it appears to me that that must fail. The other point to which I shall allude may be dealt with shortly, and that is the question of infringement. I do not say that Mr. Hunnings's criticisms upon the specification drive us to the conclusion that there is evidence. On the specification the infringement is plain enough, and it was only by way of driving us into a corner Mr. Hunnings suggested that. There was this point made as to the construction of the specification, and as to the claim of these undulatory currents. I find that the specification was originally drawn, and that fourth claim was capable of being construed as claiming the production of those currents, and it might be fairly construed so. It would have been an independent thing for Bell to rest there without disclaiming. I am satisfied that that was claimed in the original specification, and the disclaimer is not to my mind so clear as it might be. The disclaimer in one place is subject to the claims which have been mentioned. It is difficult to say what is disclaimed and what is not. I confess that, looking at the specification, and understanding the invention as I think I do, it appears to me if we acceded to Mr. Hunnings's argument that the specification is altered by the disclaimer, we should be doing that which was never intended, and construe a document, capable of two constructions, in such a way as to render it invalid rather than otherwise. It is our duty to ascertain the true construction of the document; but, of course, in ascertaining what is the true construction, I take it we ought to apply our judgment to specifications in the same way as to other documents. It strikes me that Mr. Justice Fry is right when he says, if we put the construction upon this amended specification Mr. Hunnings asks us to do, we should be doing what is an absurdity. That appears to me to be a course which no Court should take. It appears to me that is the construction, and this specification is free from the objections urged against it. The conclusion I have come to is that the specification is good, and that the anticipation is not valid.

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ORIENTAL TELEPHONE COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Thursday, 8th inst., at the offices of the Company, Col. G. E. Gourand in the chair.

The SECRETARY (Mr. W. G. Hall) read the notice convening the meeting, and the minutes of the previous meeting were read and confirmed.

The CHAIRMAN said that the unavoidable absence of the chairman of the Company (John Pender, Esq., M.P.) accounted for his being in the chair. He remarked that the business was of a purely formal character, assuming the meeting approved of the resolutions passed at the last meeting, but the Articles of the Company made it necessary that all proceedings of the Company in extraordinary general meeting should be subsequently confirmed by a meeting of the shareholders.

The resolutions passed at the extraordinary general meeting held on the 24th January were then duly confirmed. In reply to a question asked by a shareholder as to the progress of the Company since the last meeting,

The CHAIRMAN said that not much time had elapsed since then, but something of a very important character had nevertheless been accomplished. Mr. Pender, at the last meeting, stated that negotiations were proceeding for the formation of an important subsidiary company, viz., one for Calcutta, which, he explained, would be upon the same lines as those of the Bombay company, with which they were familiar. The negotiations in question had so far reached a conclusion, that all the principal points are settled; indeed, this much has been done within the last twenty-four hours. A telegram had been received, giving the names of the proposed directors, and all those of a most satisfactory character. The terms might be generally expressed as advantageous to the Oriental Company as in the case of Bombay; in fact, more so, as a larger payment was to be made in cash, as well as in shares; but by this remark he did not wish it to be understood as implying that the terms were any less favourable to the Calcutta Company. As on the occasion of the last meeting, when Mr. Pender was able to report a satisfactory progress of the exchanges in Alexandria and Cairo, he was able at this time to say that this progress had continued, and even exceeded the anticipations of himself and his colleagues. An important circumstance might be mentioned in evidence of the favour with which the enterprise was regarded in Egypt, as well as the approval of the Egyptian Government, of the manner in which the Company had managed its business in these two places [hear, hear]. The Khedive had recently extended the grant to the Company, which originally was limited to Cairo and Alexandria, so as now to include practically all the important towns in Egypt. As originally explained by Mr. Pender, the Company was to develop the business in all the places of importance throughout the wide field of the Company's operations. After having demonstrated its utility, local companies were to be formed with local capital and support. He (Colonel Gourand) said there had been enquiries from Egypt with a view of purchasing the shares of the Oriental Company, which seem to indicate that telephone shares would be regarded with favour in that country. The Board had therefore determined to form a separate company for Egypt, and in order to accomplish this had recently registered in England a company under the style of the Telephone Company of Egypt (Limited). The Board had been fortunate in obtaining as chairman Lieut.-Gen. Fraser, late Secretary of the Public Works Department of the Government of India, a gentleman of very great experience and ability. The other directors so far appointed were himself (Colonel Gourand), deputy chairman, and Mr. James Pender.

The CHAIRMAN, replying to a further question, said that it was the intention of the Board to declare an interim dividend, pending the arrival of the accounts from abroad, which must of necessity be somewhat delayed, owing to the wide distribution of the Company's interest; but notwithstanding this, through the efforts of the manager and secretary, Mr. Hall, whose services were of the greatest value to both the Company and directors, this delay would not amount to much. The Chairman added that the amount to be now paid as interim dividend on the ordinary shares would be 2½ per cent., but he hoped that something more substantial would be paid in the course of the next few months, when the annual report and accounts to the 31st December last would be submitted to the shareholders. The amount of this further payment would necessarily rest with the shareholders themselves.

A vote of thanks to the chairman brought the proceedings to a close.

[The above report appeared in our Special Edition of Saturday last.]

THE DIRECT UNITED STATES CABLE COMPANY.

The half-yearly ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel, on Friday, the 9th inst. John Pender, Esq., M.P., presided.

The SECRETARY having read the notice calling the meeting,

The CHAIRMAN said: Gentlemen—The revenue for the half year to 31st December last, after deducting out-payments, amounted to £77,469 8s. 3d., and the working and other expenses, including debenture interest and income-tax, absorb £22,786 3s. 2d., leaving a balance of £54,683 5s. 1d. as the net profit of the half year, making, with £282 16s. 8d. brought from the previous half year, and £324 12s. 1d. reserved last half year for law charges, a total of £55,290 13s. 10d., which has been appropriated as follows:—Interim dividend of 5s. per share to 30th September last, £15,177 10s.; interim dividend of 5s. per share to 31st December last. £15,177 10s.; written off preliminary expenditure, £2,213 4s. 1d.; set aside to reserve fund, £21,435 13s. 9d.; carried forward to next half year, £1,286 16s.—total, £55,290 13s. 10d. The revenue, at the 2s. tariff, exhibits an increase of £12,955 over that for the corresponding period of 1881; but a comparison of the receipts is again unreliable, owing, firstly, to the 1s. tariff having been in operation during the five months ending December, 1881, and, secondly, to the arrangements concluded in May last with the American companies. The revenue at the present tariff of 2s., however, may, no doubt, be considered satisfactory. Turning to the expenditure, it will be seen by Abstract A, page 8 of the accounts, that the expenses in London remain practically the same as in 1881, but the expenses at stations, as shown by Abstract B, page 9, exhibit a substantial reduction, amounting to about £3,400, due principally to the arrangements entered into with the Western Union Telegraph Company in May last. The only item showing any appreciable increase is that of repairs and renewals to buildings, the additional outlay in this case having been incurred in placing the Company's station buildings at Ballinskelligs in a sound state of repair. On the whole the working and other expenditure shows a reduction of £2,788, as compared with the corresponding period of 1881. The present market value of the Company's investments, standing in the balance sheet at cost of £296,053 12s. 5d., is about £307,000, or, say, £11,000 (equal to 4 per cent.) more than their cost to the Company. The annual interest from these investments will now amount to about £11,000. Now, gentlemen, these figures I think must be very satisfactory to you, and as the past half year has been one rather remarkable in its incidents I thought it necessary to go, perhaps, a little more into detail to-day than usual, so that you may not only understand exactly the position which your Company occupies at the present moment, but also that you may have a fair idea of Atlantic telegraphy as well. When I had the pleasure of addressing you six months ago there were many rumours of further competition from new cables. We had just concluded our agreement with the American Cable Company, and a working arrangement with the Western Union Company of America. We had given the 1s. tariff a fair trial, and the result was so unsatisfactory that the various companies interested were obliged to revert to the 2s. tariff. We are now more convinced than ever that the 1s. tariff does not sufficiently influence the telegraphing public to make them increase the number of their messages to such an extent as would give us the same amount of money at 1s. as we can earn at 2s.—in short, the 1s. tariff would not yield enough to enable us to pay much more than our bare working expenses. We then found ourselves in the face of a new threatened competition, which had been talked of in America, connected with two powerful elements, the one being headed by the chairman of the Baltimore and Ohio Railway, and the other by Mr. Bennett, of the *New York Herald*—two men occupying important positions. They complained that, owing to the first cable arrangements which had been made, they were placed entirely in the power of the Western Union Company, and that it would be impossible for them to carry on an independent land line system with success unless they had the privilege of sending their messages on the same terms as those enjoyed by the Western Union Company or had cables of their own. I found it very difficult to meet this argument, and, with a view to better understand the whole position, and also with a view to have our arrangement modified, if possible, so as to have an independent system of Atlantic telegraphy, I proceeded to New York, determined to inquire into the whole question. On my arrival there I found that by this time the Western Union Company had entered into an agreement with the American Cable Company, so that the Western Union Company was literally working and controlling on the American side the whole of the trans-Atlantic cable traffic. And I found merchants, newspaper proprietors, and others all denouncing in no measured terms what they called this vast monopoly which had been established, and which they regarded as detrimental to their interests. I represented this state of affairs to some of the leading members of the Western Union Company; but, before going fully into the question, I resolved to travel over a great part of the Western Union system, so as to enable me to judge of how far that system was entitled to the position which it had assumed on the American continent. I may mention that, during my stay in the United States, I travelled something like 9,000 miles. At every point that I stopped at while I was there, even where the population was very sparse indeed, I found the Western Union represented. And here let me take advantage of this, the first public opportunity I have had since my return home, to express my cordial thanks to the heads of the various railway systems in that country for the extraordinary facilities they afforded me over their various railroads, and for the great attention and courtesy which I invariably met with at their hands. I may say, gentlemen, accompanied by one or two American friends, that we had every luxury that could be possibly placed before us, and we travelled over that 9,000 miles without its costing one shilling to this Company—entirely at the cost of the American railway systems. I think that is most creditable; at all events, we can do nothing of the kind in this country, and, therefore, I am sure that you will agree with me that at a meeting like this, where we are addressing our shareholders, we should one and all recognise the generous treatment which your chairman received. I also especially desire to take the same opportunity to convey my heartiest and best thanks to the Western Union Company. At New York the president, Dr. Norvin Green, and the general manager, General Eckert; at Chicago the general superintendent of their western division, Colonel Clowry; and, in fact, all I met connected with the company, were everywhere unceasing and successful in their efforts to make my visit to their country both interesting and instructive. I visited some of the most important cities and a vast deal of territory as yet unoccupied, but in the course of being developed, more particularly that portion which the Northern Pacific line traverses. Along the whole route the territory is very much as nature made it; but at the stations along the railway towns are springing up, which in a few years are likely to become important centres. Population seems to accumulate there by leaps and bounds, but even where this growth of population had only began I found that the Western Union had established offices; in short, I was struck with their omnipresence. That their system not only covers an enormous area, but that it is well and efficiently worked was to my mind an undoubted fact, and if the American people could be satisfied with one telegraph system, I believe that it could not possibly be done better than by the Western Union Company. They have in the West at Chicago, St. Pauls, Denver, Omaha, St. Louis, Cincinnati, in fact at all the leading important towns, men of the highest intelligence, and evidently men who have not only developed the Western Union Company, but have also made an important position for it and for themselves. This fact alone gave me great confidence in the working of the Western Union system, and I felt that the arrangements we had made with them were fully justified as enabling us, through our trans-Atlantic cables, to reach all points throughout the United States and Canada with the least possible delay. On the other hand, I found that there were many who thought the monopoly injurious, and who were more or less instrumental in getting up small competing lines. I was not astonished at this, but felt that it would have shown wisdom on the part of the Western Union Company if they had not endeavoured, as they had done so frequently, to buy up these small competing concerns, which were brought out evidently for the purpose of being sold at a profit. It would, in my opinion, have been better for the Western

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Union Company if they had shown, by their vast organisation, that they were able to carry traffic more promptly and efficiently than any competing company. In short, the contrast would have been so apparent, and so much in favour of the Western Union Company, that I believe that such competition would rather have benefited them than otherwise. These eight competitious rather benefit than injure the Western Union. This I have strongly represented to the Western Union Company. I have always held that opinion. I hold it now, and I think we have carried it out, so far as the public is concerned, in the system of submarine telegraphs over which I have the honour to preside. Gentlemen, having satisfied myself on the efficiency of the Western Union system, and endeavoured, as far as I possibly could, to avert competition, I called upon Mr. Garrett. I may say that that gentleman is chairman of the Baltimore and Ohio Railway. He is a man at the very head of railway companies in America, a man of high honour and integrity, a man that is very much esteemed and valued by the people of Baltimore. I had the honour of making his acquaintance in England, and I received from him a thorough hearty welcome. When I visited him I went into the question of the competition which he was about to establish with Mr. Bennett. I explained to him the policy which I thought might, if carried out, suit his purpose quite as well as putting down cables of their own—in short, better. The result of that conversation was that he said he would be satisfied if that policy was carried out, and that at all events he would be disposed to give it a fair trial. I afterwards had a similar conversation with Mr. Bennett, and the result was pretty much the same, so far as what I may call the Garrett-Bennett opposition. I believe for the time that that is at an end. However, I do not say that upon any distinct authority from those gentlemen, but they have now made arrangements for giving the system, as they said then that they would, a fair trial. I considered that he had reason on his side, and I am glad to inform you that we have now succeeded in establishing the policy of an independent office in New York, which the Direct Company and the French Company work entirely independently of the Western Union Company. And here let me say that, since we entered into arrangements with the French Company, we have received their most cordial co-operation. We have found them, as we expected, loyal in every way. I went over to Paris, and reported the result of my mission to America, and received a most hearty recognition of what had been done, and an expression of their thorough appreciation of the advantages which were likely to result therefrom. I think that the establishment of the independent office in New York ought to satisfy not only the American telegraphing public, but also those who have been instrumental in bringing out competing land lines to the Western Union. I have thought it desirable to refer to my visit to America, and to say something about the Western Union system, because it is a system which is probably, in its efficiency, only to be compared with our own system in England, which is worked by Government, with this difference, that being worked by private enterprise, and being stimulated more or less by competition, I think the Western Union have shown greater results during the last ten years than our system has under Government management. I think that the science of electricity has received more encouragement, and has been more developed. The reduction of rates has during that time also been greater in America than in England, and altogether I think it would be well if our Government took a leaf out of the book of the Western Union Company. Having said this much about the land telegraph system of America, I must now say that I believe that to have a thoroughly efficient system of telegraphy, not only between New York and Europe, but also between New York and the vast territories of America, telegraphs must be worked under such arrangements as will give the lightning its full value and force. It would never answer if any one company had power to stop any message. The systems must be so organised as to be what I may call an universal system of telegraphy. This has always been our policy, and I shall always continue to develop it. I have had experience in our Eastern cable system, in which, owing to working arrangements, there is uniformity, and which connects all the centres of trade throughout the world, and there is no point in that system at which there is any stop or friction. To illustrate speed and uniformity between international telegraph systems, I may refer to an instance which occurred on the morning of Sir Garnet Wolseley's decisive victory in Egypt. At about ten o'clock (local American time) on that eventful morning the train in which I was travelling stopped at a little station on Indian territory, in Nebraska, and I received a despatch informing me of the English victory, and I was able to telegraph there and then to Sir Garnet that from a land where civilisation is only dawning I sent him congratulations to the land of the Pyramids, and I may say that these telegrams were exchanged in less time than is represented by the difference of hours between the two points. I may now say that probably our Atlantic system was never in a more satisfactory position than at present. There are eight cables. We are all working amicably and at a moderate tariff. We have established an independent office in New York to meet the requirements of those who felt there ought to be two distinct systems instead of only one, and I cannot see, therefore, at the present moment, any excuse for the laying of additional cables, because all the reasonable requirements of the general public have been met by the policy which we have now carried out. With regard to the threatened competition, which I will call the Garrett-Bennett scheme, although I am not authorised to say that they have entirely abandoned the idea, still they are satisfied with the arrangement we have made, and are giving it a trial. I may, therefore congratulate you and the Atlantic companies generally on the fact that we have before us—for some considerable period at least—freedom from that dread of more cables which has so materially damaged the value of our property in the market. There has also been an idea that if any one were to lay an Atlantic cable or cables the existing companies would be sure to step in and purchase them at a profit. I think I may say without hesitation that that time has gone past. It is true that an extraordinary transaction took place between the American Cable Company and the Western Union Company, which gave an enormous profit to the Cable Company; but I do not think for one moment that such an arrangement is ever likely to take place again, and it would, therefore, be well for those who have an idea of promoting companies for the purpose of getting a large profit out of them to remember that the present cables are equal to more than double the amount of traffic now carried, and that there is not another Company either in England or America which would be likely to enable them to realise any profit upon cables which had been promoted simply for the purpose of gain by sale, and not by legitimate working. Although I have not referred to the Anglo Company, which is, after all, the senior company, having four cables and receiving the largest share of the receipts, I may mention that their managing director has throughout been consulted in all these matters, and that he is thoroughly in accord with us in the policy which we have so successfully carried out. But the suggestion of the policy and the expense of carrying it out rests with the Direct Company. It may be well to say a few words as to the present value of Atlantic cables, as you constantly hear the cry of the capitals being watered, &c. No doubt the capitals of the different companies have been largely watered, but it matters very little what the portion of water is. The real question is, what is the value of the cables to-day? Take, for instance, the Anglo-American Company. They have four cables, three of which are comparatively young; the fourth (or what may be called the Brest cable) is the oldest cable at the present moment operating in the Atlantic. Last summer the Anglo Company spent £90,000 in repairing it. This not only gave them a living cable, but established the fact that a cable twelve years old could be picked up in 2,000 fathoms, proving that the strength of the cable still exists, and we know now, from experience, that the gutta percha—the heart of the cable—does not decay. Therefore, we may assume that this twelve year old cable may be as good for the next twelve years, and, probably, a much longer period, as it is now. Those four cables of the Anglo Company would cost to replace at the present moment from 3½ to 4 millions sterling. They carry with them the goodwill, which is worth a very considerable sum, having a monopoly of shortest route. They were the pioneers of this deep sea system of telegraphy, and are entitled to some monetary compensation on that account, but what is the market value of those cables to-day? Just about the price that I have named. Therefore the watering is perfectly understood, and is taken into account by the general public. Now take the French Company. The capital of that company is £1,680,000, they have one cable only, which, through financing and other circumstances, has cost them a very large sum of money; but what is the market value to-day?—why, about £800,000. The Direct Company's capital has been the least watered, but what there is was introduced into it before the present Board had anything to do with the Company. To replace our entire cable would cost about £900,000, the value in the market is about £800,000. It is now nearly six years since the management has been in our hands, during which period we have regularly paid a dividend of 5 per cent. per annum, and in the same period we have placed £290,000 to reserve. At the same rate of progress, in another six or seven years we shall have enough money in our hands to procure a new main cable, but as our knowledge of cables is daily becoming more complete, as was instanced the other day by the picking up and repair of the Anglo Company's Brest cable, I hope to find that, by the time our reserve fund is sufficient for a new cable, that our present cable is still working, and still likely to last for many more years, in which case we should be able to defer laying another cable, and consequently the interest from our investment of the reserve fund would provide us with a large revenue, in addition to the ordinary revenue earned by the existing cable. We should then, in fact, have two sources of revenue. But the most remarkable company is the American Cable Company. They made two cables, costing them less than £1,400,000. They leased these cables to the Western Union Company for fifty years for £2,800,000, to give 5 per cent. upon this increased value, or, say, 10 per cent. upon the original cost: but notwithstanding this high rate of interest, and the nature of the bargain, which restores to them at the end of fifty years their cables in as perfect working order as they are now (which means, I should think, new cables), I say, notwithstanding all this, the market value of these cables to-day is about £1,900,000. But, unfortunately, at the present moment, this transaction of the American Cable Company with the Western Union is so well known that there are promoters who now argue that if they can lay two cables they are very likely to make (as they say the American Company have made) a million sterling by the transaction. They make a great mistake. They look at the million as immediate profit, but ignore the fact that if those cables were sold at their market value to-day they would show a very small profit indeed. Besides, as I have before said, there is no likelihood of a second transaction of this kind taking place in America, and such a transaction would be quite impossible in England. I think these remarks are necessary quite as much for our own shareholders as for the general public, and good advice, if they choose to take it, to those promoters who are so anxious to benefit themselves by getting further competing cables for the Atlantic under the guise of being public benefactors, but whose first consideration is how they can make money by the operation. At present there is no better telegraph service in the world than the Atlantic service. I believe the public generally are now satisfied, and I hope that with quiet we shall so develop the traffic as to be able to increase our reserve if not our dividends, but, whether one or both, to increase the value of our property, and public confidence in it as an investment. I now beg to move:—"That the report of the directors, dated the 1st day of February, 1883, together with the statement of accounts for the half year ending 31st December, 1882, annexed thereto, be, and the same are hereby, adopted."

The resolution was formally seconded by Mr. W. FORD.

Mr. GRIFFITH: Your speech, Mr. Chairman, is so full of information and instruction that I cannot but suggest that it would be an advantage to us if we had an opportunity of considering it more at our leisure. You have given us a sketch of the whole system of telegraphy, and have shown us what able measures have been taken in America, and you have also entered upon other topics which are most important, and I would suggest that the speech to which we have listened should be printed, and a copy sent to each member. We shall then be able to appreciate more the great efforts which have been made in our services.

Mr. JOHN NEWTON: I suggest that the next time you give us a little more time. There is a most important Anglo meeting going on, and although we should like to stay here, we really must leave, because we want to attend. I think the one point you have mentioned of your visit to America is of such vast importance, that really on this side of the table I think some acknowledgement should be given on the part of the shareholders for the cordial welcome you received.

The CHAIRMAN: Previous to this we have held the meetings at twelve o'clock, and the Anglo-American meetings have been held at two o'clock. The Anglo-American made their meeting at twelve o'clock, and so we arranged for ours at 11:30, but as I know there are many anxious to go there, I am

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only sorry that my remarks have kept you so long. He then formally put the resolution, which was carried unanimously. He next said, will any gentleman propose the election of an auditor?

Mr. JACKSON: I beg to propose that Mr. John Sawyer be and is hereby elected one of the auditors. I will not detain the meeting under the circumstances that have been gone into, but still I wish to say, while I propose this gentleman, he is a shareholders' nominee, and I have satisfied myself that he is a most efficient gentleman, and well acquainted with the accounts, and he has been concerned in auditing the accounts, and he is a brother of the late auditor. He is, besides, auditor for several public companies of very great importance, amongst which I mention the *Graphic* Newspaper Company (Limited), and, therefore, I think he is a man in every way entitled to our confidence. But I may call attention to the fact that hitherto we have had a rather meagre note appended to the accounts, and in the future I think it would be desirable to enter more into detail, stating that the auditor has compared with the books the vouchers, the certificates, and all these matters of detail. He should state that all those had been thoroughly examined. With regard to the other auditor, Mr. Griffiths, I may say that he has given me personal satisfaction, and he used at one time to state that he had gone through all the securities of the Company, and satisfied himself of their existence.

Mr. HINTON formally seconded the motion.

The CHAIRMAN: Mr. Griffiths would like to say a word on this subject.

Mr. GRIFFITHS: I beg to assure you that the duties of auditors have been very thoroughly fulfilled. We have examined everything that it was possible to examine. I am thoroughly satisfied, but I never like to put a long certificate on accounts of this sort. If I detailed some of the work I have done questions might be asked as to whether I have done more or not, and I have satisfied myself of the existence of all the securities referred to in the balance-sheet.

The motion was then put and carried unanimously.

The CHAIRMAN: I think, gentlemen, if there are no further remarks, that closes the business.

Mr. JOHN SAWYER: I beg to return thanks for the honour you have done me in electing me auditor. I appreciate that not only on account of the Company, but to be associated with Mr. Griffiths, whom I have known now for some considerable time, and I am able to say that your accounts are thoroughly looked after and very efficiently audited.

The CHAIRMAN: That concludes the business.

Mr. JACKSON: It would be most uncourteous to separate without a vote of thanks to the chairman and directors. I beg to propose that the best thanks of the meeting be given to the chairman and board for their services during the past half year.

A SHAREHOLDER formally seconded the motion, which was carried unanimously.

The CHAIRMAN: Gentlemen, on behalf of my colleagues and myself we only regret that our time has been so limited to-day, because there is nothing pleases the Board and myself so much as to have the criticisms of our shareholders. We come here before you once in six months. We think you are entitled to inquiry, and although we give you the best information we can on the business, still there are always some minds who can find some spots that may be worth considering and discussing.

The proceedings then terminated.

[The above report appeared in our Special Edition of Saturday last.]

ANGLO-AMERICAN TELEGRAPH COMPANY (LIMITED).

The ordinary half-yearly meeting of the above Company was held on the 9th inst., at the City Terminus Hotel, Cannon-street, the Hon. Robert Grimston presiding.

The SECRETARY (Mr. T. H. Wells) having read the notice convening the meeting, the report of the directors was taken as read.

The CHAIRMAN said: In the unavoidable absence of the chairman, Lord Monck, from illness, I have been requested to occupy the chair on this occasion. I must ask, therefore, gentlemen, for your kind indulgence, hoping that you will take the will for the deed. In one respect I appear before you under very happy auspices, and that is that all our cables are in good working order [applause]. When we met here six months ago, our Brest cable, or as it is generally called our 1869 cable, was broken in mid ocean; and a gentleman, who assumed the name of "An ex-Stockholder," went to the trouble and expense of circulating amongst the proprietors two letters, in which he prophesied that the 1869 cable never would be repaired, for that it was practically defunct and utterly useless. A man who prophecies about submarine cables is a very bold man indeed, and he would do well to remember the old distich—

"The easiest way to increase your store
Is to prophecy after and not before."

[Laughter]. Now within a very few weeks of the "ex-Stockholder's" prophecies, they were all falsified; the 1869 cable was repaired, and it has worked splendidly ever since. It carries on an average 4,000 words a day, and it could carry treble the amount if it were required [cheers]. The cost of repairing this cable has been very large indeed, very much larger than your directors had any reason to expect when they sent out the expedition to do it. In some respects we were somewhat unfortunate; upon two occasions when the work was very nearly completed, in fact I had been told that in another hour the work would have been done, the wind got up, and the cable had to be buoyed. Then the storm carried away the buoys, and this and the grappling of the cable had to be done over again. The result was that this expedition lasted between four and five months, and what with the value of the new cable that was expended it has come to the large sum of more than £90,000. We shall not have to go and borrow the money at a high rate of interest, for we have it in our renewal fund, and the whole cost of this expedition will be borne by that fund. Now, consider for a moment what would have been the position of this Company if we had no renewal fund. When our 1865 cable failed we should not have been able to replace it with a new cable as we have done; and, again, when our 1869 cable failed we should not have been able to replace it with a new one. And without the money in our till I do not think we could have ventured to send out a costly expedition to repair this 1869 cable, so that we should have been a Company with one cable, and that cable twelve years old. That would have been the position of the Anglo-American Telegraph Company if you had not had the prudence to sanction the additions which we have made from time to time to the renewal fund [applause]. Thanks to the renewal fund, we have now four cables in good working order. Now, in the seventh paragraph of this report allusion is made to our having raised the rate of tariff from one shilling to two shillings a word; and I wish to make a few remarks on that subject. We were induced by the desire of the public to make the experiment of the one shilling tariff, and I must confess I was one of those sanguine persons—if you will not apply a harsher term to it—who believed that a shilling tariff would amply repay all the companies, that there was business enough for all, and that this would become permanently the tariff of the future. We tried this experiment for ten months, and most grievously was I disappointed. The public, who were ready enough to cry out for a reduction of the tariff, were not quite so ready to bear their share of the expenses. In the result they did not support us in the manner we had a right to expect from so liberal a reduction. In the ten months during which we carried at the shilling tariff, as compared with the corresponding ten months at a higher rate, not this Company only, but the joint-purse, lost £290,000, or at the rate of very nearly £1,000 a day. Well, gentlemen, will anybody have been surprised that we entered into an arrangement with Mr. Jay Gould, a part of which arrangement was that the tariff should be put up to 2s. The public, I am sure, have no right to complain; they would not support us; it is their own doing, and they forced us into it. I have here a comparative statement of the tariff after we had raised it, and of the tariff before we had raised it, and that is very instructive. In August, 1882, our receipts were £70,430; in 1881, at the 1s. tariff, they were £51,690. In September they were £85,550, against £51,920; in October, £93,740, against £52,440; in November £89,390, against £49,860. There is a difference for the two latter months of £40,000 each. In December they were £78,150, against £50,280; and in the last month—January—they were £83,930, against £47,630; making altogether an increase for the six months of £206,670. Is it, then, to be wondered at that we entered into that arrangement with Mr. Jay Gould? Now, gentlemen, with respect to the accounts, I think there is very little to remark upon. The only thing I have to say with regard to the accounts is that, in salaries and wages, there is a saving of rather more than £550. In the general balance-sheet there is one item that requires explanation—sundry creditors, £125,731. The fact is that we have not yet paid to the Telegraph Construction and Maintenance Company an amount of £80,000 pending its adjustment, but we have the money all ready on deposit, and I expect that we shall make the payment some time in the course of next week. There is one other matter on which I wish to say a word before I sit down, and it is this. I regret to have to announce the resignation of my friend Mr. Rate, a gentleman in whom I have the greatest confidence, and upon whom I relied very much for advice at all times. I am sorry to say that he has now retired from the Board, and the directors have elected in his stead a gentleman well known to people who have anything to do with Atlantic telegraphy, I mean Mr. Cunard, and I hope he will worthily fill Mr. Rate's place. Gentlemen, I will now move "That the report of the directors and accompanying statement of accounts to the 31st December, 1882, submitted to this meeting be, and the same are, hereby received and adopted; and that the following dividends, all free of income-tax, be now declared—that is to say, a balance dividend of one per cent. upon the ordinary stock for the year ending 31st December, 1882, making with the previous payments two and three-fourths per cent. on that stock for the year 1882; secondly, a balance dividend of two per cent. upon the Preferred stock for the year ending 31st December, 1882, making, with previous payments, five-and-a-half per cent. on that stock for the year 1882" [applause].

Sir DANIEL GOOCH, Bart, M.P., briefly expressed his pleasure in seconding the motion.

Mr. BROWN asked whether there was not £36,000 over the corresponding period of last year, and how it was the poor Deferred shareholders got nothing?

The CHAIRMAN replied that there was not a sufficient balance of revenue account to pay any additional amount beyond what the directors proposed to pay.

Mr. JOHN NEWTON said he was sorry their meeting clashed with that of the Direct United States Cable Company, which was held about the same time, as he was anxious to get all the information he could as to these properties. If the shareholders of the Anglo-American Telegraph Company present at this meeting had heard the speech of the chairman of the Direct Company some half-an-hour before, they would have felt the greatest satisfaction as to the excellent working condition of the cables of the two great companies. The oldest cable they had been working, as he heard from the chairman of the Direct Company, was some ten years old.

Mr. HENRY WEAVER: Thirteen.

Mr. NEWTON: Well, thirteen. That had been picked up from the bottom of the sea, from a depth of 2,000 fathoms. This had put cable property on the footing of a good investing property. They might look to the future, perhaps, three times as long as they might have otherwise looked, and feel that their property would in perhaps 20 or 30 years be in the same condition by expending a small sum of money from year to year upon it. They would, therefore, hope to continue to derive satisfactory returns when they took into consideration the market value of their property.

A SHAREHOLDER remarked that he thought the Deferred shareholders had some claim to consideration [hear, hear], and that they ought to have some portion of the £36,000. If they were allowed one half per cent. it would be something of an encouragement to those who had been waiting a long time and who had received nothing. He, therefore, moved as an amendment that they should have one half per cent. paid out of the reserve fund.

Mr. POTTS said he thought the last speaker was under a misapprehension. If he were not mistaken the Articles of Association stated that the Preferred shareholders must receive 6 per cent. before the Deferred shareholders could receive a sixpence [applause].

The SHAREHOLDER said if his motion were not regular he would withdraw it.

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Mr. POTTS said, inasmuch as the Preferred shareholders only recieved 5½ per cent., at present the Deferred shareholders had no case.

Mr. WEAVER: You are quite right.

Mr. GRIFFITHS expressed his regret at the absence of Lord Monck, who was a gentleman of undoubted talent, full information, and genial manner. He agreed with the chairman as to the advisability of the arrangement with Mr. Jay Gould, but he doubted whether it would not have been better to have entered into that arrangement before the war rather than subsequent to it. The chairman had told them that the war cost them £290,000, or £1,000 a day, and they might have saved that sum, and thereby have increased their dividends—at any rate, the dividends of the Deferred—and at the same time have made their Company much more secure. He thought their past policy had been a fear of bogies, and was glad there were signs of that policy being given up, and a more peaceable one being adopted. Mr. Pender, who had been in America, had told them that there was a very ill-feeling growing up there because the Western Union had monopolised the whole of the land traffic, and that, in consequence, numerous bodies objected to being under such control, and were likely to start new cables, in order that they might be independent of it. Mr. Pender said that the Western Union system was developed in a wonderful manner, but it was creating a feeling against its central tyranny. He also told them that he had made arrangements by which the Direct and the French Company might have a separate office in America. The consequence would be that there would not be this ill-feeling in the future on the other side of the Atlantic, and for some time to come they need not anticipate any rivalry from new cables. He thought they might look forward to a more settled state of affairs, and trusted the large reserve fund they had would not be used to place more cables under the water, for he understood that those which they possessed could carry more than double the messages that could possibly be sent. He hoped the reserve fund would be applied to equalising the dividends from time to time [hear, hear]. The Preferred shareholders would then get their interest, and the Deferred shareholders would look forward with confidence to some return.

Sir H. JOHNSTON said the accounts were of a very meagre character, and he thought they were entitled to have some further explanation of the £100,000 and upwards which was put under one head.

The CHAIRMAN said there was an item of £19,027, balance of account, owing to the Western Union Telegraph Company of America. They also owed £2,407 to the Postmaster-General, and £2,678 in traffic balances to the Eastern Telegraph Company. Any proprietor could obtain every information at the office. With regard to the cables, there was no intention to increase their number [hear, hear], but they had to keep them in working order [applause]. They could not tell the life of a cable. Two—the 1865 and 1869 cables—had failed within ten years. One of their present ones had lasted between thirteen and fourteen years, while they had two others, one of nine and the other of eight years.

The resolution was put to the meeting and carried unanimously.

On the motion of the CHAIRMAN, seconded by Sir Daniel Gooch, the Marquis of Tweeddale and Mr. Cyrus W. Field were re-elected directors of the Company.

The auditors, Mr. Joshua Dean and Mr. Francis Glass, were subsequently re-appointed for the current year, at a remuneration of £100 per annum each.

A vote of thanks to the chairman closed the proceedings.

INDIA RUBBER, GUTTA PERCHA, AND TELEGRAPH WORKS COMPANY (LIMITED).

The nineteenth ordinary general meeting of this Company was held at the City Terminus Hotel, Cannon-street, on the 13th inst., under the presidency of Mr. George Henderson.

The SECRETARY (Mr. William J. Tyler) having read the notice convening the meeting,

The CHAIRMAN said: We are very glad to meet you with so good a report, and to put before you accounts showing such excellent results of the year's business, enabling us to distribute a handsome dividend, as well as to strengthen the Company's financial position by so material an increase to our reserve. As our business increases so also must the reserve, in order to supply the requisite working capital. How to place our new buildings and machinery within the limited space at our disposal has been a matter of considerable difficulty and anxiety to our manager, Mr. Gray, but this he has successfully overcome. As regards our factory at Persan-Beaumont, we have been obliged to acquire additional land to connect our place with the railway, and to give room for necessary extensions. Our chief cable expedition—that for laying the Central and South American cable — was carried out under the management of Mr. R. K. Gray, and both he and his staff deserve the thanks of the shareholders. The Company's cable ships are all in first-rate condition. The "Dacia" and "International" are now under charter, and the "Silvertown" is on her way home with a freight which will go towards her coal bill and other ordinary expenses. We hope that the proposal to do something for our workpeople will meet with your approval. Mr. Gray will give you some information as to how we intend to proceed in this matter, but I may just mention that, in the interest of employer and employed, we think that those of our people who come to their work from a distance should have a comfortable place in which to take their meals, and that, by means of lectures and classes, they should have opportunities of self-improvement and training to fit them for doing their work efficiently and intelligently, and that rational entertainment and recreation should be provided for their leisure hours. I may mention that it is only proposed that the first cost of erection should be borne by the Company, the cost of maintenance and everything else by the workers themselves. I do not know that I need detain you longer, but we shall be happy to hear any shareholder who may desire to address the meeting. He then moved the adoption of the report and accounts, and the payment of a dividend of £1 a share and a bonus of similar amount.

Mr. S. W. SILVER: I have very great pleasure in seconding that.

Mr. DIXEY stated that he was not a very large shareholder in the Company, but having been connected with it for many years he might express the intense pleasure and satisfaction he had felt in reading the report which had been submitted to the meeting. It was pleasant to find that every department in connection with the Company had been fully employed during the past year, that the item of debentures and securities in other companies had been greatly reduced, that certain securities had been disposed of at a considerable profit, and it was also pleasant to find that £100,000 had been added to the reserve fund, and that after paying 25 per cent. to the shareholders there yet remained a balance of £36,311 to be carried forward to next year—a sum almost double that which was carried forward in the previous year. He ventured to say that a report such as that had seldom been submitted to any body of shareholders, and they might well congratulate the directors and each other that day upon the prosperity which the Company had attained. There was, too, a paragraph in the report to which he had not yet alluded, but which had struck him as constituting its grandest feature, and that was the suggestion made by the directors to appropriate the sum of £6,000 towards the building of dining rooms and a hall for the comfort, instruction, and amusement of the workpeople at Silvertown. That was a proposal which appealed at once to their highest and best instincts, and one which he trusted would commend itself to the great body of the shareholders; for it could not be denied that the workpeople at Silvertown had contributed to the success, in some degree at least, on which they congratulated themselves that day. They were indebted to the directors for the sagacity with which they had taken the conduct of the affairs; they were indebted to Mr. Gray, the manager, for his business tact and his indomitable zeal and energy; and they were indebted to the secretary and other officials for the interest they had taken in the Company, but behind the directors, the manager himself, and the foremost officials he had mentioned, there were latent forces which they were too apt, perhaps, to overlook and ignore, but which were, nevertheless, absolutely essential to the success of an undertaking such as theirs. The latent forces to which he referred were the workpeople at Silvertown, and it was impossible to say how much they were indebted to them for their sobriety, industry, and skill. He must say that he heartily rejoiced in the suggestion of the directors: he considered it a noble one, and trusted it would be followed by other companies. If employers generally would only show the same spirit of consideration and generosity which was now about to be shown by this Company, the vexed question of capital and labour, which was now agitating the community, would, in his opinion, soon reach a pacific and permanent settlement, and there would, he said, be an indissoluble bond of union established between employer and employed. He had had a great deal to do with working men, and he knew that they were not lacking in gratitude and appreciation. Some years ago it fell to his lot to visit very frequently the works at Silvertown, and he always found the people there ready to receive instruction, and to welcome that highest form of instruction called religious instruction. He heartily welcomed the suggestion of the directors, and trusted ere long that it would develop widely into a scheme which would redound to the credit and honour of the Company.

A SHAREHOLDER presumed that the entire reserve fund was employed in the Company's works.

The CHAIRMAN: The whole is employed in the Company's works. It is all wanted.

The SHAREHOLDER inquired up to what amount it was intended to raise the reserve fund.

The CHAIRMAN: Really we cannot answer that question. As our business increases so must our reserve.

The SHAREHOLDER asked how the reserve was appropriated.

The CHAIRMAN: In whatever is wanted for the works and the business. It is not invested in anything particularly.

The SHAREHOLDER inquired how, in that case, the reserve would be available in case of loss on contracts.

The CHAIRMAN: The whole of our available capital is available for losses. I hope there will be nothing of that sort.

Mr. HANCOCK observed that in their previous accounts they had had the amount shown for profit or loss, as the case might be, on the sale of investments. In the present account, however, the amount was not stated, but as the profit of the half year was large he thought they might naturally conclude that there had been a considerable profit on the sale of investments. He inquired the amount so realised.

The CHAIRMAN: It is not usual for us to disclose where our profits come from. We are a trading company, and I must object distinctly to stating from what sources our profits come.

Mr. HANCOCK repeated that in previous accounts the amount was set out, and as the profits on the sale of investments did not concern those derived from manufacturing, the chairman's reason for not giving the information did not apply. The amount of profits in a year would vary immensely if they were made up of two unknown items—one from manufacturing and the other from the sale of investments. He need not say how much pleasure it gave him to congratulate the Company on the present state of its affairs. Their profits now came to as closely as possible the sum which he (Mr. Hancock) stated, before the company was started, to Mr. John Harvey, the first chairman of the Company, as the profits they might reasonably expect to secure if they had a capital of £250,000 to £500,000. Another great satisfaction to the shareholders, no doubt, would be the fact that in the past year—in fact, for some years past, though more especially in the past year, and there was every probability of it extending—immense ingenuity had been displayed in connection with electric and telegraphic matters. All this would tend to bring them profitable orders, and the progress so far made was likely to be enormously developed. The progress of the telephone and the electric light must, he said, inevitably produce them an increased amount of profit without any particular amount of extra labour, except in the extension of machinery and of the works, the extra profit arising from the orders being four, five, six, or eight times as large as previously. They might, therefore, reasonably conclude that the state of affairs laid before them on the present occasion was one which was likely to be repeated, and in all probability it would improve. He had also been exceedingly pleased with that portion of the report to which a previous speaker had alluded—the appropriation of £6,000 towards furthering the interests of the workpeople. Having had so much to do with workpeople himself, he knew very well the importance of attaching the workpeople to their work, and keeping them as near as possible to

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their place of work rather than allowing them to wander elsewhere for their amusement and recreation.

Mr. SINCLAIR thought Mr. Hancock's observations called for a few remarks. The directors offered them on the present occasion not only a good dividend but also a good bonus, and he thought they might, without going into the matter very carefully, consider the profits represented by the dividend and the reserve, and the amount carried over by what had been derived from extraneous profits which would, probably, not arise in other years. He thought that that should be remembered. When a dividend of 25 per cent. was paid there were some persons who were very apt to think that they ought to receive the same distribution again. He hoped that they would, but he thought they should be satisfied for the return on their capital which was represented by the dividend only. He joined in the congratulatory remarks which had been made, and he congratulated the management on having brought the Company through its difficulties.

Mr. A. R. JOHNSTON observed that there was no doubt that the dividend of 25 per cent. was a very handsome and gratifying one, but he thought it was only right to draw the attention of the meeting to the fact that the actual profits had been over 60 per cent. As the shareholders received 25 per cent., there was a balance of 35 per cent. remaining, leaving a large margin supposing the profits were not so good in the future. He, therefore, did not think it was right to suggest that they should not look forward again to getting 25 per cent. It was not likely, for instance, that they were going to put by £100,000 every year to reserve fund. The point of his remarks was that they should not depreciate the future prospects of the Company, as had, he thought, been done by the previous speaker.

The CHAIRMAN then put the motion, and declared it carried unanimously. Continuing, he moved the re-election as directors of Messrs. S. W. Silver and Neil Bannatyne.

Mr. JOHNSTON seconded the motion, observing that the gentlemen named had been most energetic in promoting the interests of the Company.

A SHAREHOLDER, however, stated that the task of seconding the motion had been deputed to him. He seconded the resolution with great pleasure. He was one of the directors of the company many years ago, when it was struggling to master its difficulties, and he was glad to know that they had been mastered, and that the progress of the concern had been so decided.

The CHAIRMAN put the resolution, and it was carried unanimously.

Mr. SILVER: It remains for me to acknowledge and to thank you for this evidence of your confidence in us, and to express a hope, and a very strong hope, that we shall continue to preserve the confidence which you have placed in us. We shall do our utmost to deserve it, so that when the time comes we may merit a renewal of it at your hands.

Mr. BANNATYNE briefly endorsed the remarks of Mr. Silver.

On the motion of Mr. H. A. SILVER, seconded by Mr. SINCLAIR, the auditors, Messrs. J. Weise and Abraham Scott, were reappointed for the ensuing year.

The GENERAL MANAGER (Mr. Matthew Gray): I have to put before the meeting this resolution:—"That the directors be and they are hereby authorised to expend out of the funds of the Company a sum of about £6,000 in the erection of a hall and dining rooms on the Company's property." Before I say a word in respect of this resolution let me congratulate the shareholders on the position the Company is now in, and on the handsome profits made from the last year's business. The only reason I refer to that is that I want to warn the shareholders that, although we will do everything we can for them in the future, the past year was an exceptional year. I beg you not to think that it must be repeated—I hope it will be, and often, but I do not want that any shareholder should have an idea that what you receive on the present occasion is what you are always likely to receive. I do not wish to depreciate the property. I have been very ably seconded by all the staff, who work very well for the interests of the Company. As to the workpeople, I endorse the remarks of the gentleman who pointed out that we must not forget that they have aided us in earning the money we have earned. Some of the shareholders may not know it, but about twenty years ago the little works of Mr. Silver were placed in a marsh, the level of the ground being 8ft below high water mark, and the water only kept out by the river wall. We have gone on building works, and houses have been erected in the neighbourhood, but with all the care we have been able to bestow on the place it is not a very desirable locality for any one to live in; and we have had difficulties in getting the workpeople to reside close to the works. It has, therefore, been our desire to make them as far as possible comfortable, and to supply them with proper machinery and well-ventilated rooms. I think the 1,500 workpeople now in our employ are about as comfortably supplied as they can be in the workshops, and as for the appliances inside I do not think I am wrong in saying that they are second to none in London or elsewhere. It has been a work of labour. The work, however, has been done, and I think done well. We ask you now to vote this sum of money, and I do so with a great deal of pleasure. It is needed. Some of the workpeople come from a long distance, and they have no place to go to to have their meals. We want to give them this accommodation, and to provide them with a comfortable place. We, therefore, propose building a dining room for the women and another for the men, where their food can be warmed, and where they can have comfort and shelter in their dinner time. We also propose to build four class rooms, two libraries—a library where the newspapers and books will be handed out by the librarian, and a library where a man can read a book, and smoke his pipe, and make himself comfortable. We further propose building a hall to hold about 600 or 700 people, where lectures and concerts can be given and enjoyed in comfort. The district about there is increasing, and such a place is wanted very much. In anticipation that such accommodation would be provided, we started, some little time ago, the Silvertown Institute, and the teaching has been very successful. Some of the students have been examined at Kensington, and also at Guildhall, and I think they have taken five gold medals, eight silver medals, and several certificates. By and by, when this hall and class room are built, the place will not be handed over to them, but they will get it at a nominal rent, and they will thus have a place where they may combine amusement and instruction close to their work.

Mr. J. O. HANSON seconded the resolution, and it was carried unanimously.

A vote of thanks was then passed to the chairman and directors, and,

The CHAIRMAN having briefly acknowledged the compliment, the proceedings terminated.

THE TELEPHONE COMPANY (LIMITED).

The final meeting of this Company (in liquidation) was held at the City Terminus Hotel on the 26th ult., under the presidency of Mr. Charles Schiff.

The CHAIRMAN said: Gentlemen, it is my duty to report to you now the result of the liquidation of the Telephone Company, and I am happy to say that it has been carried out completely, and with satisfactory results. In point of fact every shareholder of the Telephone Company (Limited) has received one share in the United Telephone Company for every share held in this Company, and as you know the shares of the United Company have been sold as high as 8, 9, or 10. The shareholders have also received two distributions of 10s. each, and I am able to distribute another 2s. 5d. as a final distribution. We have had £9,369 of debts to pay, and the whole cost of the liquidation has amounted to £562 6s. 2d. On the other hand we have received cash, for interest on our deposit pending the liquidation, to the amount of £399 18s. 1d., so that practically the cost of the liquidation has been less than the amount of interest you have earned pending the liquidation. I do not think I have anything more to add, and I shall therefore put this resolution, and after that is passed the cheques for the 2s. 5d. final distribution will be at once forwarded. I beg to move this resolution:—"That the liquidator having laid before this meeting an account showing the manner in which the winding up has been conducted, and its property has been disposed of, resolved, that the same be, and is hereby approved and adopted."

Mr. H. D. BIRD formally seconded the resolution, which was carried, and the proceedings then terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES FEB. 14.		BUSINESS DONE WEEK ENDING FEB. 14. Highest.	Lowest.
Anglo-American	49½,	50½	51	50½
Do. Preferred	80½,	81½	83½	83½
Do. Deferred	18½,	18¾	18¾	18½
Brazil Submarine	12¾,	12¾	12¾	12¾
Cuba	9½,	10½	--	—
Do. Preference	16½,	17½	—	—
Direct Spanish	6½,	6¾	—	—
Do. Preference	16,	17	16½	16½
Direct United States Cable	12,	12½	12½	12
Eastern Telegraph	10¾,	11	11 1-16	10¾
Do. 6 per Cent. Preference	13,	13½	13½	13½
Do. 5 per Cent. Debentures, 1899	103,	106	—	—
Eastern Extension	11¼,	11½	11½	11¼
German Union	10¾,	10¾	—	—
Globe Telegraph and Trust Company.	¼,	6½	6 11-16	6 9-16
Do. Preference	12¼,	12½	12½	12 11-16
Great Northern	12,	12¼	12½	12
Indo-European	32,	33	—	—
Mediterranean Extension	1¾,	2¼	1¾	1¾
Do. Preference	6,	8	—	—
Reuter's	10½,	11	—	—
Submarine	260,	265	260-2	260-2
West India and Panama	1¼,	1½	1 7-16	1¼
Do. 1st Preference	7,	7½	—	—
Western Brazilian	7¾,	8	7¾	7¾
West. Union 7 per Cent. 1st Mortgage	122,	126	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	—	—

TELEPHONES.

Consol. Telephone and Maintenance	¾,	1	1	¾
Oriental	¼,	¾	1 3-16	¾
United Telephone	11½,	11¾	12 3-16	11½

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	5½,	5¾	3-16	5½
Do. (fully paid)	8½,	9¼	10	9½
Hammond Light	3,	3½	3 7-16	3½
Eastern Electric (65 p.c.)	1,	1½	—	—
Pilsen, Joel, and General Electric	¼,	1	¾	¾
Swan	2¼,	2¾	2¾	2¾
Maxim-Weston	¼,	¾	5-16	¾

TRAFFIC RECEIPTS FOR JANUARY, 1883.

COMPANIES.	Jan., 1883.	Jan., 1882.	Increse.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	3,021	—	221
Direct Spanish Telegraph Company	1,689	2,055	—	366
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	32,822	33,129	—	307
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	18,240	17,110	1,130	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SLIP

German Union Telegraph Company.—The next meeting of this company will take place on March 9.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended 16th instant amounted to £3,824.

To be Wound Up.—A petition for the winding up of the Electric Carbon Company is to be heard to-day (Saturday), before Vice-Chancellor Bacon.

A Contrast.—The cost of taking out an American patent for seventeen years is about £7, whilst in England the same patent would cost about £200 for 14 years.

The Charing-cross Electric Railway.—The Corporation of London have resolved to petition Parliament against the Bill for the construction of this railway.

Electric Lighting in Spain.—The Tarragona, Barcelona, and French Railway Company is about erecting ten Gramme arc lamps to light its principal station.

A New Paper.—*L'Electricidad* of Barcelona is announced as the latest recruit to join the ranks of journalism devoted to electricity. It will be a bi-monthly publication.

"The Electricians' Directory."—*The Electricians' Directory* for 1883 is now published, and may be had from this office, or through any bookseller. The price is 2s.

Gas at Hull.—The British Gas Light Company has reduced the price of its gas supply at Hull to 1s. 10d. per 1,000 cubic feet. Ten years since the corresponding price was 2s. 6d. per 1,000 cubic feet.

Postal Telegraph Appointments.—Mr. J. Donaldson, Telegraph Superintendent at Reading, has been appointed Postmaster at Trowbridge; and Mr. J. Gregson, telegraphist at Rochdale, Postmaster at Workington.

Royal Society.—On Thursday last Mr. W. H. Preece, F.R.S., was to read the following paper before the Royal Society, viz.:—"The Effects of Temperature on the Electromotive Force and Resistance of Batteries."

A Fort Struck by Lightning.—Recent news from the Transvaal states that one of the forts erected for the investment of Mapoch's stronghold had been struck by lightning. One man was killed and 28 men wounded by the flash.

Electric Lighting for Ships.—The Electric Carbon Storage and Apparatus Company have received instruction to light up the ss. "Buninyong," now lying in Sandon Dock, Liverpool, with incandescent and arc lamps throughout.

The Telephone Case.—The solicitors of the United Telephone Company, Messrs. Waterhouse and Winterbotham, deny that Messrs. Harrison, Cox-Walker, and Co. have lodged an appeal in the House of Lords against the recent decision.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 16th February, 1883, were £2,523, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

Mr. Brush's Storage Battery.—The English patent taken out by Mr. C. F. Brush, through his agent, for a system of storing electrical energy occupies no less than 46 pages of print. The number of the patent is 3108, and it is dated 1st July, 1882. We shall give a brief abstract of it in an early issue.

Savoy Theatre.—A performance of *Iolanthe* was given at this theatre on Thursday week for the special entertainment of the theatrical profession. All the fairies, together with the principal peris, wore electric lights in their hair for the first time. Only a few of the principal fairies had previously worn them.

Electric Lighting on Trains.—The experimental lighting of trains running between Brussels and Antwerp has been put a stop to for a short period, to permit of certain modifications in the plant. It has been found difficult to obtain a sufficiently constant current, and it is with the object of insuring this that the temporary cessation of the lighting has been ordered.

Electric Lighting in Edinburgh.—Messrs. John Mitchell and Son, art furnishers, 106, Princes-street, Edinburgh, have arranged with the Electric Carbon Storage Company, Leith, to have their windows and part of their premises lighted up every evening with incandescent lamps, worked by means of storage batteries, in order to show the effect of the light upon interior decoration, colour, and furnishings.

An Army Telegraph Corps.—Lieut.-Colonel Du Plat Taylor, commanding the 24th (Post Office) Rifle Volunteers, has received instructions from the Secretary of State for War to form an army telegraph corps which might take the field in time of war. The nucleus of this "sister service" to the Army Postal Corps is a company raised principally from the Postal Telegraph Branch, which will be recruited to a strength of 200 rank and file, and supplied with the necessary field equipment.

Applications for Provisional Orders.—According to a report by the Board of Trade on the Bills of the Session, there are 106 applications for provisional orders relating to electric lighting, the capital proposed being £2,752,778. According to the list of provisional orders applied for, given in Vol. X., p. 91, of *The Electrician*, and reprinted in the *Electricians' Directory* for 1883, there were 152 applicants. Comparing this with the Board of Trade report, it will be seen that of this number, 46 have allowed the matter to drop on Mr. Micawber's principle, we suppose.

More Exhibitions.—It is reported that an electric exhibition is to be held in Spain this year, and will open on the 21st December next. The locality is not mentioned by our authority.—An electric exhibition is to be held in Königsberg, in Prussia, and will open on the 15th of April. The committee of organisation includes the names of Dr. Albrecht, director of the Technical School; Dr. Saalschütz, Professor at the University; Herr Sack, councillor; Herr Seidel, director of Telegraphs; and Herr Seydler, apothecary. We believe that the time for sending applications for space has gone by.

Electric Lighting in Sunderland.—A trial of Gülcher arc lamps has lately been made at Lambton Drops, Sunderland, where the operation of loading coal vessels is carried on. The trial has so far been very successful, enabling vessels to be loaded long after dark, or in fact all night long if required. The dynamo, a Gülcher, is driven by one of Tangye's high speed vertical engines. The Gülcher, like the Edison, is a low tension system, and in all cases where ordinary labourers having no knowledge of electricity are liable to come into contact with wires or lamps, this is a consideration.

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ELECTRIC LIGHTING AND GAS.—The president of the Midland Association of Gas Engineers, Mr. H. Woodhall, of Leeds, is good enough to acknowledge that "the activity and spirit of enterprise which now pervades the (gas) profession," is no doubt due to "their friend the electric light" and its "quickening influence." The public might add that the lowering of gas charges, and the better lighting of the streets in many towns is also due to the same "quickening influence." Gas engineers have been quickened into a trot lately, but they must break into a gallop soon if they do not want to be left behind.

ELECTRIC LIGHTING FOR THE HOUSE OF COMMONS.—It has been stated, says the *Daily News*, "that the use of the electric light is to be extended in the House of Commons, and that the corridors and other parts of the House are to be lighted by the incandescent lamp. On the contrary, the electric light in Palace-yard will henceforward be discontinued. There is a proposal to light the Commons dining room and the library by the incandescent light, but the matter has not gone beyond the stage of consideration." The system in use in the Palace-yard is the Brush. The system proposed for use in the dining room, &c., is, we believe, Edison's.

THE ELECTRIC LIGHT IN SHOPS.—The practical application of electricity to the lighting of shops is being shown on the premises of Messrs. Robinson and Sons' Italian warehousemen, Upperhead-row, Leeds. Two storage batteries are used to feed a series of incandescent lamps, the current to which passes through a number of automatic commutators encased in a box, and by means of which the current is divided, so that it may be carried into distant parts of the building. All risk of accidents from fire caused by a sudden interference with the even flow of the current is removed by plugs, which will, at a temperature of 205deg. Fahr., release the switch of the commutator and secure another, and, under ordinary circumstances, more perfect connection.

A PARADOX.—The Clerkenwell Vestry have had the light given by the Maxim incandescent lamps, which have for some time past been lighting Pentonville-road, tested as to its quantity and quality. Mr. Grimwood, one of the gas examiners of the Metropolitan Board of Works, reported that the lamps in question gave no less than 18 candles more light than was originally stipulated for by the vestry. They wanted 50, and have got 68 candles out of the lamps. Notwithstanding this, however, the special Lighting Committee of the vestry have reported that in their opinion "incandescent lamps are not suitable for out-door lighting." We are not in possession of the full report of the committee, and it is possible there may be something hidden therein which may explain the somewhat paradoxical opinion arrived at by the committee; as it stands, however, we confess to being a little puzzled.

ELECTRIC LIGHTING AND THE FIRE BRIGADE.—An amusing incident occurred on the evening of Thursday week, in connection with some experiments carried on at Messrs. Unwin Brothers' printing office, Little Bridge-street, E.C. At about half-past eight o'clock the neighbourhood was suddenly and brilliantly illuminated by a glare from the first floor windows. A cry of "Fire" was instantly raised, and the neighbouring fire escape and a pair of engines were soon on the spot. The street was thronged with people, but the firemen soon found out they were not wanted. An opposite neighbour, however, was so alarmed that he commenced immediately to move his furniture. The cause of the disturbance was the lighting up of a very powerful "search light," as used by the navy, the carbon of which is 1¼in. in diameter, and capable of giving a light equal to 100,000 candles. This lamp was maintained by a current from an Elphinstone-Vincent dynamo. The effect was splendid, and the crowd who remained greeted the exhibition with an appreciative cheer at the close.

THE INVENTORS OF DYNAMOS.—The following list of the best-known names of inventors of dynamos will be interesting:—Brush, American; Bürgin, Swiss; Edison, American; Elmore, English; Elphinstone and Vincent, English; Ferranti (we do not know Mr. Ferranti's nationality, but we do not think he is English); Gordon, English; Gramme, French; Gülcher, Austrian; Higgs, English; Hopkinson, English; Jablochkoff, Russian; Lumley (the inventor of the dynamo known as the "Lumley" is an American, we believe); Maxim, American; De Meritens, French; Pilsen, Austrian; Schückert, German; Fein, German; Siemens, German; Weston, American; Wilde, English. Reducing this list to numbers, we get the following figures:—American inventors of dynamos number 5, Austrian 2, English 6, French 2, German 3, Russian 1, Swiss 1, and 1 doubtful (Ferranti). Summing up these figures give us 15 foreign inventors of dynamos against 6 English. It says something for England, however, that nearly all these 15 dynamos are to be found in London, and most of them are made there.

ELECTRIC LIGHTING AT LIVERPOOL.—At the meeting of the City Council of Liverpool on Wednesday, a lively discussion was occasioned by a recommendation from the Library Committee to accept a tender for repairing the dynamo which supplies current to the lamps in the Public Library. The sum of £140 was thought to be a great deal for the repair of a dynamo, and it was suggested that whilst the council were about it, they might as well get a larger machine, which would supply current for the lamps in the library, and at the same time to others, which it was suggested should be placed in St. George's Hall. According to a member of the council, it costs a very considerable sum of money to periodically re-decorate the hall, owing to the black deposit occasioned by the present gas burners. It was pointed out, however, by another member, that the money available for St. George's Hall came from a different source to that which was applied to the library purposes. In the end it was agreed that the Finance, Library, and Watch Committees should go into the question and see what could be done.

TELEGRAPH CLERKS' GRIEVANCES.—A large and enthusiastic meeting of telegraph clerks was held at Manchester on Saturday night last. The following resolution was adopted:—"That this meeting desires to record its dissatisfaction with the scheme of revision lately applied to the telegraph services, inasmuch as it fails in many instances to satisfy the just claims of the clerks as set forth in the united petition in 1881, and cannot accept it as a final settlement." The "miserable recognition" by the Government of the services of telegraph clerks was freely commented upon, and the Central Committee were urged to take immediate steps to obtain a parliamentary inquiry into their grievances. It was pointed out that, whilst telegraph clerks in London were paid for their Sunday services, it was "repeatedly and unjustifiably" denied to their provincial brethren. The meeting expressed its gratification at Mr. Fawcett's recovery from illness, and tendered its cordial thanks to him for his earnest endeavours to ameliorate their condition; and also to mem-

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bers of Parliament, the Press, and the public for the support which had been accorded to the agitation.

THE TRANSMISSION OF POWER BY ELECTRICITY.—M. Hospitalier thus sums up the results of the Miesbach-Munich experiments of M. Marcel Deprez, in a recent issue of *La Nature*. He says that the experiments established the following fact, viz. :—"Two Gramme machines, type A, identical in every respect, wound with fine wire, can, when the generator exerts an effective mechanical work of 100 kilogrammetres per second (1·33 h.-p.), transport to 60 kilometres distance, over a line of about 1,000 ohms resistance, an effective power of 20 kilogrammetres per second ($\frac{1}{4}$ h.-p.), with a mechanical return of 20 per cent. and an electrical return of 40 per cent." After criticising the arrangement of machines and conducting wire at the recent experiments made by M. Marcel Deprez in the workshops of the Northern of France Railway, of which he was an eye-witness, M. Hospitalier says :—"The experiments made at the Northern Railway will have no meaning until the day when the line is subjected to conditions such as external influences exercise on the elements of the transmission of power of the same kind and the same power as actually occurs under the normal conditions of practical working."

PICTURESQUE ELECTRIC ILLUMINATION.—The electric light has been applied of late in various cases, where the effect has been singularly picturesque. Thus, during a congress of Greek medical men at Athens last year, several electric lamps were placed at elevated points about the Acropolis, and the aspect of the ruins so lit up is said to have been very striking. The Company of Steam Navigation on the Rhine and the Lake of Constance started last year a night service of steamers supplied with Bürgin electric lamps to illuminate the beautiful banks of the river. The steamer left Schaffhausen at fall of night and sailed to Biesingen, and passengers were enabled to enjoy the scenery in those novel circumstances. Further, the falls of the Rhine have been illuminated at night by a powerful electric light placed on the right bank. To appreciate fully the remarkable appearance of the foaming torrent so lit up it is necessary to reach the principal rock, on which is a small pavilion, and where the stream divides into two large parts. Again, there is a regular night service instituted between Cannes and the Lerin Islands, the vessel being the steam yacht "Cannois," which has a powerful Mangin lamp, also thirty-four Swan lamps, arranged between the masts and elsewhere. The electric light guides the course in the difficult navigation which often occurs in these trips and furnishes many lovely views of scenery.—*The Times*.

COMPOUND STEEL AND IRON ELECTRO-MAGNETS.—We take the following from a patent recently issued to Messrs. Ayrton and Perry (No. 3036, dated 27th June, 1882, price 6d.) :—"The first part of our invention consists in the use of a combination of steel and wrought iron in the field magnets of a dynamo electric machine. The steel and iron may be combined together as a tube of steel enclosing a wrought-iron core, or a tube of wrought iron enclosing a steel core, or alternate tubes of wrought iron and steel enclosed within one another, or alternate plates of steel and wrought iron, or any combination of these arrangements. We find that a dynamo machine with field magnets of this kind behaves to some extent like a combination magneto and dynamo machine, and the result is, that with a proper arrangement of winding, at a certain speed, it is possible to obtain a constant electromotive force between the two ends of the outside circuits, whatever be the resistance of the outside circuits; and with other arrangements of winding, and with other speeds, it is possible to obtain a constant current through the outside circuit. In fact, we are able to obtain either constancy of electromotive force or constancy of current, so that whether we work incandescent lamps or motors in parallel circuit, or lamps or motors in series, we get a very large increase in steadiness that enables one motor or lamp to be independent of all the rest."

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—A petition for the confirmation of a special resolution passed by this company for reducing its capital came before Mr. Justice Pearson last week.—Mr. Rigby, Q.C., appeared in support of the petition, and stated that it was not intended in any way to interfere with the rights of creditors. The company consisted of 69,000 shares of £20 each, every one of which had been issued, and every farthing paid up. At the time they were formed into a company they were also concerned in another company, called the Central Company of America, which turned out to be a failure. Money was lent to finance the Central Company, and in 1866 the company was wound up, the sole asset of the company being a telegraph cable somewhere in the Caribbean Sea, which, after examination, turned out to be worthless. The whole of the portion of the capital invested in that company was therefore lost. As the petitioners wished that the share capital should be properly represented, they asked the leave of the Court to reduce their shares to £15, thus striking off one-fourth of their share capital. They further asked that they might be permitted to advertise the amount of the capital of the company as fully paid up, and without the addition of the words "and reduced."—His Lordship said he thought that this was a very honest step on the part of the company to desire that their capital should be properly represented, and not to have it supposed that it was one-fourth more than it really was He should, therefore, grant the application.

ELECTRIC LIGHT WIRES IN INDIA.—"It is somewhat unfortunate for the electric light companies," says the *Times of India*, "that their operations should be impeded by the danger which the presence of their wires causes to the ordinary telegraph wires. Some months ago the Municipal Commissioner of Bombay addressed Government suggesting that the telegraph wires should be so hung as to permit a clear headway of thirty feet to allow for the possible laying of electric light wires throughout the municipal limits of Bombay. Thereupon the local Government referred to the Government of India, which, under date of the 2nd inst., wrote back stating that 'no such general request as that of the Bombay Municipality can be attended to,' as the orders of the Supreme Government require that a clear interval of thirty feet shall be maintained between the wires used for electric lighting and the ordinary telegraph and telephone wires. This, under present circumstances, can be secured in most cases in which the lines are parallel by laying the electric light wires at a sufficient distance from the overhead wires horizontally. There may, however, be cases in the streets of a city in which the interval of thirty feet cannot be secured without raising the telegraph wires or lowering those of the electric light, and in all cases of crossings the Government of India direct that one or other of these alternatives be adopted. Each case must be decided on its own merits, both with regard to priority of occupation of the ground and to the comparative cost of raising or lowering."

ANOTHER IMPORTANT TELEPHONE DECISION.—The long litigation between the Bell Telephone Company and the Dolbear Telephone Company came to an end in the Circuit Court, at Boston, January 24, victory resting with the former. In his decision Judge Gray held :—That Mr. Bell was the

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first inventor who successfully used the electric current for the transmission of articulate sound. The differences of Dolbear's and Bell's plans are not such as to warrant the former to claim an invention of the entire system. The essence of Bell's invention consists not merely in the form of apparatus which he uses, but in the general process, or method, of which that apparatus is the embodiment. Notwithstanding the distinct difference claimed by the Dolbear receiver, they avail themselves of Mr. Bell's discovery that undulatory vibrations of electricity can intelligently and accurately transmit articulate speech, as well as of the process which Bell invented and by which he reduced his discovery to practical use. They also copy the mode and apparatus by which he creates and transmits the undulatory electrical vibrations corresponding to those of the air. And in the plate charged with electricity, which they have substituted for the magnetic coil in the receiver, the charge constantly varies in accordance with the principle which Mr. Bell discovered, and by means of the undulating current caused by the process and in the mode which he invented and patented. The defendants have, therefore, infringed on Bell's patent by using his general process or method, and should be restrained by injunction from continuing to do so. —*Scientific American.*

Severe Thunderstorm in Zante.—We have received the following from a correspondent in Zante:—The island of Zante was visited recently by one of the most severe thunder and hail storms ever known. The lightning was most vivid, and struck several buildings and trees, both in the town and surrounding country. A large flagstaff, situated on the mole of the Eastern Telegraph Company's quarters, was most beautifully struck. The electric discharge struck the round block at the lanyards, smashing it to atoms. From thence it passed, serpent-like, all down the pole, leaving a splintered groove three inches wide and two deep, right away to the stone-built base, which was split into various pieces by the current in its passage to earth. There is not the slightest trace of fire on any part of the pole, its appearance being rather the result of an axe than of the electric fluid. Several cables run in the immediate vicinity of the flagstaff, but they were in no way affected, nor was it necessary to put the wires to "earth" there, except on one circuit (recorder) for a short time, although the lightning lasted the entire night. Much damage was done by the hail, or, rather, blocks of ice; one piece was picked up weighing fourteen ounces. In one village not a single earthenware tile is intact, and in many places a quantity of large and small birds have been destroyed. Subsequently a violent south-easterly gale sprang up with very heavy seas, and all steamers were three or four days behind their time. It is a strange fact that this island has of late enjoyed a great immunity from earthquake shocks, hitherto of almost weekly occurrence, but, it is to be presumed, nothing will be lost by waiting.

Electric Exhibition at Vienna.—We have received the following additional information with reference to the electric exhibition which it is proposed to hold in Vienna this year. It appears that his Imperial Highness the Crown Prince Archduke Rudolph of Austria has consented to become a patron of the exhibition, and takes great interest in it. His Majesty the Emperor has, through Prince Hohenlohe, given an order to Carl Giani for the production of a very handsome pavilion to be shown at the exhibition. It is intended to drape the interior of this pavilion with rich hangings and embroideries, and to light it up by means of different systems of electric lighting, so as to show the adaptability of the electric light for the purpose, and also to afford a means of comparison between various systems. The extent which the exhibition is likely to reach may be estimated by the fact that the motive power which will be required has been fixed at 1,000 h.-p. About 700 h.-p. is intended to serve for lighting the exhibition buildings and grounds. The boilers and engines employed will, in the majority of cases, be of the fixed type, although portable boilers and engines will not be excluded. All boilers and engines of whatever type will be objects of exhibition. It has been proposed to arrange the boilers and steam engines as they would be if erected for permanent work, and so that they may be easily inspected by visitors. The machinery department will thus offer a good opportunity to engineers of making valuable comparisons. Although such an arrangement will considerably add to the expenses, nevertheless the Commission has consented to sacrifice a greater amount of money in order to secure an opportunity of general instruction, and thus hasten the solution of the important question—how to construct boilers and engines for electric lighting purposes.

A Christmas Card.—We have this week received a copy of a Christmas and New Year's Card for 1882-83, which has been sent us by the officers of the Post and Telegraph Department of Queensland. It is a specimen of one that has been sent, we believe, to all Australian offices. It is very neatly, not to say artistically, got up. It is folded in the centre, and has, therefore, four faces. On the outer face we have photographic coloured views of some chief towns in Brisbane and their post offices, with an elaborate border. Inside we find a list of the chief postal and telegraph officials of the colony. The latter, we may mention here, are Mr. A. F. Matveieff, Superintendent of Telegraphs, and Mr. R. O. Bourne, General Inspector for the Northern District. We also make acquaintance with the following facts, viz., that the colony was established on December 10, 1859; that its population in 1860 was 28,056, and in 1881 226,968; and that the telephone system was established October, 1880. Numerous statistics are given which are interesting, thus we find that the revenue from telegraphs in 1860 was only £938, whilst in 1881 it was £43,940, against an expenditure, in 1860, of £1,652, and in 1881 of £62,124. We may note here that the colony borrowed £439,138 for telegraph construction works in 1881. The number of telegraph offices in 1860 was 7, in 1881 it was 170. The number of messages transmitted and received in the same two years was 6,189 and 661,464, a large increase. Finally, the number of miles of line in 1861 was 169, and there being only a single wire line then, the miles of wire were represented by the same figures; in 1881, however, the miles of line had increased to 6,203, and the miles of wire to 9,089. The back of the card contains what we presume to be an artistic representation of tropical vegetation and a tropical sky, in the centre of which is to be found the greeting and good wishes sent by the Queensland Post and Telegraph Department to their colleagues. We must congratulate the compilers and originators of this Christmas card on their production, and beg to thank them for their good wishes, so far as we are concerned.

Electricity, its Characteristics and Uses. — This was the title of a lecture delivered during the week at Queen-street Hall, Edinburgh, before the members of the Philosophical Institution, by Mr. J. H. A. Macdonald, Q.C., A.S T.E., &c. The lecturer remarked at the outset that electricity was a subject about which we should all soon require

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to know something practically, because it seemed extremely likely that it would come inside our houses as a practical agent for many useful purposes. It was almost impossible for us, he pointed out, to move about for ten minutes at any hour of the day without bringing electricity into manifestation, and in illustration of this he performed several experiments, in course of which he showed that it was propagated by such simple frictional operations as the brushing of a hat, combing one's hair, and so on. It was explained, however, that the effect of the experiments was considerably neutralised by the damp state of the atmosphere. It was shown that this frictional electricity made an effort to fly off along any substance by which it could escape, and that it could only he imprisoned by the use of substances which would not, easily conduct it; while it was also demonstrated that it rested upon the surface of bodies, consequently the amount of electricity which a body could take up did not depend on the quantity of the material in that body, but on the extent of the surface which it was able to show. Speaking of lightning, the lecturer quoted from the writings of John Wesley to show that the idea of preserving buildings from the action of lightning had occurred to that celebrated divine as early as 1750. After alluding to the other practical methods by which electricity might be got—namely, chemical action, heat, and magnetism—he remarked that these were not exhaustive, because they could get electricity even from animals—there was the torpedo, from which our explosive torpedoes took their name—and no doubt it was also manifested in the growth of plants and in other ways. Altogether the lecture was very interesting. The hall was illuminated by means of 18 Lane-Fox incandescent lamps and one Brush arc lamp, the current being supplied by Faure-Sellon-Volckmar accumulators of the 1 horse-power type. The work was superintended by Mr. F. W. White, of the Electrical Power Storage Company.

New Technical College at Finsbury.—Mr. Philip Magnus, director and secretary of the City and Guilds of London Institute, delivered an opening address in the new Technical College recently erected by the institute in Tabernacle-walk, E.C. There was a large attendance of well-known men of science and others. Amongst them were Dr. Siemens, Dr. Gladstone, Sir F. J. Bramwell, Professors Abel, Ayrton, Perry, and Roscoe, and Sir Sydney Waterlow. The building has been temporarily lighted by the Edison incandescent system. We cannot find room for anything like a full report of Mr. Magnus's address, but we may quote a few sentences with advantage. He said that "considerable misapprehensions still existed as to the importance and possibilities of technical education. Some persons looked to it to remedy all our industrial shortcomings, while others failed to see its advantages or its necessity. Some again referred to science teaching as technical, while others restricted the use of the word to the teaching of an actual trade; the majority of people took a very narrow view of the extension of this term, while others were unable to understand the different kinds of training to which it was applicable. He proposed to call the training, education, or instruction, technical which had direct reference to the career of the student who received it, whether he were engineer, weaver, manufacturing chemist, or cabinet-maker. If he were asked to state in a word what had given rise to the necessity for technical education in the narrower signification of the term, he should answer the invention of the steam engine, as it was to that primarily that we owed production on a large scale, which in its turn had led to the breaking up of the apprenticeship system, thus necessitating some other kind of training. . . . . Every pupil on entering the college would declare to what industry he wished to apply himself, and then he would find a course of instruction drawn out for him on the indicated lines. As it was he thought there were several features in the curriculum of each department of the college which he ventured to think would mark it out as a new departure in educational work, and cause it to rank as intermediate between a school and a college; while the definite course of instruction laid down for each pupil would, if properly pursued, give him a wide and cultivated knowledge of the business to which he meant to devote his energies."

Provisional Orders and the Board of Trade.—An important meeting was held at the Board of Trade on Saturday, of which we take the following account from *The Times*:—"There were present Mr. Farrer, the secretary, Mr. Calcraft, assistant secretary, Captain Armstrong, the electric adviser of the Board; for the Brush Company, Mr. Moulton, Messrs. Webb (solicitors), Mr. Offor (manager), and the company's electric engineer; Mr. Mossop, chairman of the Chelsea Electric Committee, and Mr. Stayton, C.E., their surveyor; Messrs. Dyson for the Metropolitan Board, and the solicitors of St. George's and Mary-le-Strand. Mr. Farrer made a statement as to the general conclusions the Board had arrived at. They wished the local authorities to act for themselves. If two companies applied for the same district the vestry must select the company. The Board would have no bogus companies. The area of supply chosen by the company must be restricted. The company and the vestry agree on the area, and the Board would see that the company had enough means to work the area selected, and the money required must be set aside for that district. As regards the company's profits, and as to any portion of that profit going to the public, the Board would not listen to such a suggestion. The price must be regulated by competition with the gas company, and, if necessary, with other electric companies. Provision for safety against fire must be left to the public, the company, and the fire insurance companies. No meter had yet been found to satisfy the Board; but when one was found it would be introduced. Model clauses would be prepared by the Board and issued to the public in a week's time to promote uniformity. It was stated that the President did not interfere because Birmingham was so largely interested in the subject.—Mr. Mossop cordially approved the proposed conditions, but suggested that the Board might be so stringent that the parish would get no electric light. The companies were entitled to a fair profit.—Mr. Moulton was glad to find that the vestries were not the ogres they had been represented to be. He contended that besides the limited area A the companies should have a much larger area B. It was the company who had to experiment, and they ought to profit by their own experience.—Mr. Mossop said the argument simply meant that the companies were to go on learning, and the rest of the world was to rest and be thankful.—Mr. Farrer said they must agree as to their areas with the vestries. The same provisions would apply to schedule B as to A as to money and so on. Mr. Farrer pointed out that if a company went into a parish and took the cream of it and neglected the rest of the parish the Board would have power to take away some of the cream and give it to another company willing to light the poorer district.—Messrs. Dyson asked what was to be done in those cases where the vestries had determined to oppose the provisional order *in toto*?—Mr. Farrer said the parishes could reconsider that matter when the model clauses were before them."

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CURRENT ENERGY.—II.

BY OLIVER HEAVISIDE.

Given two closed circuits of any form with steady currents in them, placed at any distance apart in any relative positions, we have found (p. 223 *ante*) that the mechanical force between them may be completely defined by the variation of a certain quantity, M, which has a definite value for every configuration. Any linear displacement dx of one conductor, moving as a whole without rotation, is assisted by a real force arising from the mutual action of strength $-\frac{d\mathrm{M}}{dx}$, or the rate of decrease of M per unit displacement; and, extending the meaning of a displacement to signify any small change of position, and at the same time generalising the meaning of force so that its definition shall be contained in the statement "force × displacement = work done by the force during the displacement," we have the same relation, force $= -\frac{d\mathrm{M}}{dx}$.

This expression of the force as the variation of the quantity M is simply a reversal of the statement that M is the integral of the force. For the method of obtaining M is entirely founded upon the fact that the mechanical force between two conductors bearing currents is the same as that between two magnetic shells of the same strengths as the currents, and with coincident edges, which again is reducible to forces acting according to the law of the inverse square of the distance between quantities of magnetic matter, so that M is really the mutual potential energy of the distribution of matter. We may also say that M is the mutual potential energy of the currents, remembering, however, that the currents must not vary; for our equivalent magnetic shells are rigidly magnetised, and we so far ignore the existence of changes in the currents produced by the relative motion of the circuits.

The quantity M for the complete circuits is the same as if any pair of current elements of strengths C and C′ and lengths ds and ds', at distance r apart, one being in the first and the other in the second circuit, contributed the amount $-\overline{\mathrm{CC}}'\frac{ds\,ds'}{r}$, (equation (5) p. 225). From this we may see how the energy and the forces are affected by changes of dimensions in similar systems. For let there be another pair of circuits similar to the first, of n-fold linear dimensions, and similarly situated, so that every line joining corresponding points is magnified n times; divide the circuits into the same number of elements of length as the first pair, thus making each element n times as long; then $\frac{ds\,ds'}{r}$ is multiplied $\frac{n\times n}{n} = n$ times. Hence if the currents are the same in both cases, the energy is n times as great in the magnified system.

As for the forces, they are quite unaltered. For if dx be a displacement in the first case, it becomes $n\,dx$ in the second; and the changes in M corresponding are $d\mathrm{M}$ and $n\,d\mathrm{M}$. But the force is the change in M per *unit* displacement, and is therefore simply $d\mathrm{M}$ as before. Thus, in similar linear systems with the same currents, the forces are independent of, and the energy varies as the linear dimensions. [The law, force in similar systems unchanged, was made one of the bases of Ampère's theory, as an experimental fact; from it follows, that if the actually observed actions were due to mutual forces between the different parts of the two conductors or currents, such forces must vary as the inverse square of the distance, when the inclinations of elements are the same. This, of course, also follows from $\frac{ds\,ds'}{r}$; its rate of decrease along r being $\frac{ds\,ds'}{r^2}$.]

In varying the linear dimensions we kept the currents constant, so that it did not matter whether we varied the *sections* of the conductors or not. But, varying all the linear dimensions, if we keep the current densities constant, so that with a doubled sectional area we have a doubled current, then, since an n-fold increase of linear dimensions multiplies each of the sections n^2 times, the currents are made n^2 times as great; hence in the magnified system the energy is multiplied $n\times n^2\times n^2$, or n^5 times instead of only n times, whilst the forces are multiplied n^4 times.

This law of the fifth power, which in its application to dynamos has been pointed out by M. Marcel Deprez, is a particular case of a more general law. The potential energy of any similar distributions of matter with the gravitational law of inverse squares varies as the fifth power of the linear dimensions and as the squares of the densities. (Thomson, "Electrostatics and Magnetism," p. 435). The matter may be of the electric or magnetic kind, repulsion between like, and attraction between unlike kinds. If ρ is the volume-density and P the potential, $\frac{1}{2}\Sigma\mathrm{P}\rho$ is the potential energy, the summation including all the matter. Here $\mathrm{P} = \Sigma\frac{\rho'}{r}$ as usual; hence the energy $= \frac{1}{2}\Sigma\Sigma\frac{\rho\rho'}{r}$, where ρ and ρ' are the quantities of matter in any two elements of volume and r their distance apart. Now, in a system of n-fold dimensions, divided into the same number of elements of volume, each of them is n^3 times as large, and their distances apart are all multiplied n times; hence the energy is multiplied $\frac{n^3n^3}{n} = n^5$ times. And, of course, when the density varies, the energy varies as its square, since ρ and ρ' are both similarly increased.

But applying this law to similar magnets of different dimensions, but of the same *intensity of magnetisation*, at corresponding places, the law becomes that of the cube, not of the fifth power. This may be easily seen by comparing two similar magnets, solenoidally magnetised. If their intensities of magnetisation are the same, the surface densities of free magnetism are the same. But the law of the fifth power applies to *volume* densities, hence there is a loss of two dimensions. Or, replace the surface-density, say σ, by a volume density $\frac{\sigma}{t}$, t being the small thickness of the layer. An n-fold increase of linear dimensions with volume density constant would increase the energy n^5 times as before; but then, since t would be multiplied n times, σ would experience a like increase to keep $\frac{\sigma}{t}$ the volume-density constant; consequently, the intensity of magnetisation, which is numerically the same as the surface density, would also vary as the linear dimensions. Thus, with the intensity of magnetisation kept constant, an n-fold increase of linear dimensions of a magnet makes the volume-density (replacing the surface-density) vary inversely as n. Hence, remembering that the energy varies as the square of the volume-density, we have the energy multiplied only $\frac{n^5}{n^2}$ or n^3 times.

Yet, although the n^3 law holds for magnets with intensity of magnetisation constant, it does not hold for current systems, with the density of current kept constant, even when we replace the currents by magnetic shells producing the same fields of force. For the strength of the equivalent shell in any case is its intensity of magnetisation multiplied by its thickness, and the strength must be numerically equal to the strength of the current it replaces. Now, the latter varies as n^2 with constant current-density; hence, if the thickness of the shell becomes n times as great in the magnified system, its intensity of magnetisation or the surface-density must be also multiplied n times to keep pace with the current it replaces. Thus we have the case of similar magnets whose intensities of magnetisation vary as the linear dimensions, or of similar distributions of matter of contstant volume-densities, and therefore the n^5 law holds. [I observe, however, that Sir W. Thomson, in the paper above referred to (on p. 435) makes the cube law hold both for magnets ("polar magnets") with constant intensities of magnetisations, *and* for

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current systems ("electro-magnets," or systems of magnetic force due entirely to electric currents) with constant densities of current (or "intensities"). This may be a slip, or I may not catch the meaning correctly, or the n^5 law may not apply to currents as it appears to do.]

As regards the *magnetic* force in similar systems of current, since at a point P it is the sum of $\frac{Ch}{r^3}\,ds$ for each element of a linear circuit (p. 177. *ante*), r being the distance of P from the element, and h its distance from the axis of the current, h, r, and ds are all multiplied n times in a system of n-fold linear dimensions with the same integral current C in corresponding places; the magnetic force is therefore multiplied $\frac{n.n}{n^3}$ or $\frac{1}{n}$ times, and thus varies *inversely* as the linear dimensions. But under the same circumstances, with density of current constant, so that C varies as n^2, the magnetic force varies as $\frac{n^2}{n}$ or n, *i.e.*, *directly* as the linear dimensions.

Now, the energy is expressible, as will be seen later, also in the form $\frac{1}{8\pi}\Sigma$ (force)^2, the summation being extended throughout all space. Here (force)^2 varies as n^2 under the last-mentioned circumstances, and the volume as n^3; hence we obtain the n^5 law again with density of current constant.

Leaving now the question of dimensions, let us pass on to the more general case of the mutual energy of two arbitrary current systems. If we have a closed linear current C in presence of any number of others, C′, C″, &c., we know exactly the value of M for our selected circuit C, and any one of the others, say C′, if the rest of the system were non-existent. It is numerically C × amount of magnetic force through it due to C′, or *vice versâ*. Also, − M is the amount of mechanical work that would have to be done by external force against the electro-magnetic forces to separate C and C′ from their actual positions to an infinite distance apart, keeping the currents constant. Now, this being the case for C and C′ alone, and for C and C″ alone, when C′ and C″ exist together, the mechanical work required to remove C is simply the sum of the amounts of work done separately in the former cases. It is, indeed, obvious that the amount of magnetic force that C′ and C″ when co-existent send through C is the sum of the amounts they would separately send through C; and that the corresponding proposition is true for the work done follows from the mutual nature of the mechanical forces between the conductors, and is most easily seen to be true by replacing the currents by magnetic shells, by which we are reduced to mutual forces between sets of attracting or repelling points. In the case of the current, we may either remove C, fixing C′ and C″, or fix C and remove C′ and C″, or remove both C and the pair; but the pair must move as a rigid body without relative motion; or, if there be any, it must be cancelled later. And, in general, the energy of C with respect to any current system is the sum of its energies with respect to the individual members of the system. And here remark that we have no concern with the mutual energies of the members of the system amongst themselves.

This being true for one closed current in presence of a system, is true for a second, or for any number; and, therefore, we have the result that the mutual energy of two arbitrary current systems (arbitrary in all except that they must consist entirely of closed currents) is the sum of the mutual energies of all the pairs that can be made, taking one member of a pair from one system, and the other from the second; and, since in neither system are we concerned with the internal energy, their mutual energy is the work to be done to bring them together to their actual positions moving as rigid bodies, without internal relative motion; or, if there be such, we must not count work so performed.

For the expression of this and other results in a simple manner, it will be convenient to introduce volume-elements of current, instead of the linear elements previously used. If we have a current in a wire, and consider the latter as a mere line, we have, of course, infinite concentration of current. There is no appreciable error caused by replacing wires by lines so long as the wires are not very close together, and there will be no error if we locate the lines properly; but when we are considering currents in general, it is best to take things as they are, viz., finite currents across finite areas.

A current system may be split up into tubes of flow, which are all closed. Any tube is independent of the rest, in so far that there is no current from it to its neighbours, for it is bounded by lines of flow. Now, by splitting up the tubes into an indefinitely great number, we at the same time reduce their sections indefinitely, and also the currents they carry; hence in the limit we may treat every current-tube as a closed linear circuit carrying an infinitely small current. Let ds be an element of length of such a tube, dS its section anywhere, then $ds\,d$S is an element of volume, say, dV. Let, now, C be the current density, *i.e.*, C dS = current crossing dS, so that C would be the current across unit of area normal to the current were its density all over the unit area the same as at dS. Now, our linear element (p. 225) was integral current × element of length; this now becomes (C dS) ds or C dV. Further, we may conveniently take the element of volume to be the unit volume, since the latter may be as small as we please. We now have, instead of equation (5) (p. 225), the following:—The mutual energy of two closed currents is the same as if every pair of unit volumes, one belonging to the first, and the other to the second circuit, contributed the amount

$$-\frac{1}{r}\,\overline{\mathrm{CC'}} = -\,\overline{\mathrm{AC'}} = -\,\overline{\mathrm{A'C}} \quad . \quad . \quad . \quad (1)$$

Here, A = C ÷ r, is the vector-potential of C at C′, and A = C′ ÷ r is the vector-potential of C′ at C, r being their distance apart.

Now, applying (1) to two arbitrary current systems. We know that (1) is true when summed up for two closed tubes of indefinitely small section, and that our systems may be split up into such tubes. It follows that when we divide space into elements of volume (ignoring the tubes completely), and apply (1) to every pair of volume elements that can be made between the two systems, and sum up, we shall obtain the mutual energy, for as soon as we have finished the summation we have closed all the tubes.

Therefore, the mutual potential energy M of two systems of densities, C and C′, is

$$\mathrm{M} = -\,\Sigma\Sigma\frac{1}{r}\,\overline{\mathrm{CC'}} = -\,\Sigma\,\overline{\mathrm{AC'}} = -\,\Sigma\,\overline{\mathrm{A'C}}. \quad . \quad (2)$$

when A is the complete vector-potential of the first, and A′ of the second system. In one form we have a double summation, viz., to all pairs of current elements; in the other forms there is but one summation, because the vector-potential itself is obtained by a summation. Thus, in the form of $-\,\Sigma\,\overline{\mathrm{AC'}}$, we sum up $\overline{\mathrm{AC'}}$ for every element of the second system; here A expresses a summation over the first system, viz., $\Sigma\frac{\mathrm{C}}{r}$ (vector sum).

Corresponding to (2) these are exactly analogous expressions for the mutual energy of two systems of electrification, and the comparison is instructive. ρ and ρ' being the volume-densities of free electricity, P and P′ the potentials, and M the energy, we have

$$\mathrm{M} = \Sigma\Sigma\frac{1}{r}\rho\rho' = \Sigma\,\mathrm{P}\rho' = \Sigma\,\mathrm{P'}\rho \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Here ρ, the density of electrification, corresponds to C, the current density in (2), and P the scalar potential to A, the vector-potential. Both ρ and P are scalars, and their product is found as in algebra. But in (2) both the currents and their potentials are vectors, which is how it comes about that we have to multiply by the cosine of the angle between their directions, indicated by the stroke. As for the negative sign in (2) and positive in (3), it arises from similarly directed currents attracting, whilst similar electrifications repel.

[The following rule is useful in adding the scalar products of vectors. If A_1, A_2, A_3 . . . are any vectors whose vector-sum is A, and C is any other vector, then—

$$\overline{\mathrm{A}_1\mathrm{C}} + \overline{\mathrm{A}_2\mathrm{C}} + \overline{\mathrm{A}_3\mathrm{C}} + \ldots = \overline{\mathrm{AC}}.]$$

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SOME EXPERIMENTS IN THE TRANSMISSION OF POWER BY ELECTRICITY.*

BY GEORGE AND WILLIAM C. GIBBS.

Description of Generator and Motor.

The dynamo-electric machine used as a generator was one of Mr. Weston's latest pattern, known as the "fifty light incandescent machine." The machine used as a motor was identical with the preceding, except that it was only intended to run forty lights.

The machines were of the derived field type, that is, the field magnets were wound with comparatively fine wire, so that their resistance was about 800 times the resistance of the armature. The terminals of the field wire were connected with the brushes directly, and, therefore, when the machine was running, the magnets became charged even if the main circuit was not closed.

In this machine the magnets are horizontally arranged above and below the armature. They are essentially two horse-shoe magnets with like poles turned toward each other. The armature is wound with a continuous heavy wire, which is brought out at every turn into a loop and soldered to the commutator.

The core of the armature is made up of thin wrought-iron discs separated by small washers of gelatinised fibre. The discs are shaped somewhat like a gear wheel, that is, they have teeth on the edge to the number of perhaps twenty, and of the width of one-fourth of an inch, so that when the armature is complete there are a number of ridges running its whole length parallel to the axis. In the hollows between the ridges is wound the wire of the armature in a single layer, which, when finished, is of the same height as the ridges, making the whole a true cylinder. The ridges are called "polar extensions," for by projecting through the layer of wire they come very near to the field magnets and increase the polarity of the armature when the machine is running, and consequently the intensity of the lines of magnetic force. The core is, moreover, pierced from end to end with several holes arranged at equal angular distances apart, and the discs of which it is made up being separated from each other by the space of about a twentieth of an inch, a complete system of ventilation is kept up by the action of the machine, and the armature is thus kept cool. Each disc has also two radial slots cut in it to prevent the formation of an extra current. The commutator is composed of copper sectors separated by gelatinised fibre strips.

The brushes are of silver plated copper, each brush being composed of several strips, placed on one another, so that although the brush has great flexibility it has also sufficient springiness to cause it to press uniformly on the commutator.

Each brush is, besides, held in a spring clamp, which yields to any inequality of the commutator. The brushes are adjustable at any angle about their axis, and are in practice turned to the point of least sparking, which is the neutral plane of the machine. When properly adjusted the sparking is inappreciable.

The wire from each pair of field magnets terminates at a binding post on the top of the machine. When the generator is working to its full capacity these posts are connected by a short wire, but when it is desirable to use any part of the power of the machine, a variable resistance is placed between them. By altering this resistance the intensity of the magnetic field is varied, and the work done may be perfectly controlled. The resistance of the armature was ·03 ohm, and the resistance of the field was 24·5 ohms, measured while warm, immediately after the experiments ceased.

Description of Dynamometer.

In measuring the power to be transmitted from the engine to the generator, the Kent dynamometer built by the class of '76 of the Stevens Institute was used. In this dynamometer the receiving and transmitting pulleys are each carried by a separate shaft. These shafts are in the same straight line, and upon the ends which face each other there are two bevel wheels. A third bevel wheel at right angles to these two connects them and transmits motion from one shaft to the other. This wheel is loose upon its axis, which is prolonged to form a pendulum, and is supported by a brass pin passing through it and fitting into holes in the transmitting and receiving shafts. A heavy weight is attached to the end of the pendulum, and when the machine is running the pendulum is deflected from the normal vertical position to a position approaching more or less the horizontal.

The sine of the angle of deflection, the weight of the pendulum and "bob," and the number of revolutions per minute determine the power transmitted.

The dynamometer was standardised as follows:

The pendulum was supported in a horizontal position by a prop at a distance of two feet from the centre of the pin connecting the shafts. The lower end of the prop rested on a platform scale.

The weight indicated was 170·5lb., and since the lever arm of this weight is divided by two, by the arrangement of gear wheels above described, the weight at *one* foot is 170·5 pounds.

Then to get the power transmitted we have,

$W = 170{\cdot}5 \times \text{sine } \theta \times (6{\cdot}28 = 2\pi) \times$ number of revolutions.

Where W = work done in ft. lb. per min.

Of this power, however, a certain percentage is lost in overcoming the friction of the bearings, and must be allowed for.

To find the friction, the main and field circuits of the generator were broken, but the brushes left on the machine. A 7in. pulley was fastened on the shaft of the generator, close to the 12in. driving pulley. On the small pulley a prony brake was arranged, so that when the engine was transmitting power to the generator through the dynamometer the energy absorbed by the brake was substituted directly for the electrical energy developed by the machine when the circuits were closed.

Several experiments were made at different deflections of the pendulum.

The variation was not great, but the mean is given.

The speed was constant, and was the same as in all the experiments on the efficiency of generator.

Dynamometer:

Sine of deflection = ·33.
Weight = 170·5lb.
Radius of driving pulley = 16in.

Therefore the constant pressure indicated $= \frac{170{\cdot}5 \times {\cdot}33}{1{\cdot}33} =$ 42·3lb.

Prony brake:

Length of arm = 30in.
Pressure on scale = 7·25lb.

Pressure at circumference of pulley $= 7{\cdot}25 \times \frac{30}{6} = 36{\cdot}25$lb.

Since the dynamo pulley is 12in. diameter; $42{\cdot}30 - 36{\cdot}25 = 6{\cdot}05$ = loss by friction, and $\frac{6{\cdot}05}{42{\cdot}3} = 14{\cdot}2$ per cent. friction.

Fricton of Armature Bearings.

Lack of suitable apparatus prevented us from determining this experimentally, but since it has been found for similar machines by repeated experiment to be less than 3 per cent., and since the bearings in the machine used were as nearly perfect as skilful workmen and accurate mechanical means could make them (being a steel shaft running in gun metal bearings), we felt at liberty to assume the friction as 2·5 per cent. The bearings were oiled by continuous oilers, and the heating was so small as to be imperceptible even after long runs.

Efficiency of Generator.

In making tests for the efficiency of the generator, the current generated was carried by iron wire resistances running across the room from side to side in the open air, so that the heat generated was rapidly conducted away.

* Abstract of a Thesis written at the Stevens Institute of Technology. [This abstract has appeared in *Van Nostrand's Journal*, a specially corrected proof being sent to us by the authors.—ED. *E.*]

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A switch was so arranged that the generator could be instantly thrown out of circuit and the resistance of the line measured within five seconds. In this way the varying effect of temperature on the resistance was eliminated.

All resistances were measured by a Thomson high-resistance galvanometer. An electric lamp placed in a magic lantern threw a ray of light on the galvanometer mirror, which was reflected to a screen. This gave an immensely magnified motion to the image, so that the scale could be read from some distance in a well-lighted room.

Calorimeter Test.

In determining the electrical energy developed by this method a calorimeter was used in circuit with the iron wire resistance.

This calorimeter consisted of a cylindrical vessel of galvanised iron imbedded in sawdust in a wooden box. By this means any great waste of heat by conduction and radiation was prevented; but as some heat must have been conducted by the wood, it was allowed for in each case by taking water at the atmospheric temperature and cooling it by means of ice to as many degrees below that temperature as it was to be raised above it by the heating of the coil. In this way the transfer of heat from the sawdust to the water during the first half of the experiment was equal to the transfer from the water to the sawdust during the second half. The electrical energy expended in the calorimeter was measured by its heating effect on a coil of German-silver wire. The wire used in the coil was of No. 8. B. W. G.

The coil itself was entirely immersed in the water, and its ends were soldered to two copper rods which were fastened in the calorimeter cover. In this way the high resistance wire being entirely under water, any over-heating was prevented. The resistance of the coil was exactly ·09 ohm at 74° Fahr. in the water.

Distilled water was used in the calorimeter, it having a much higher resistance than ordinary water, thus diminishing the tendency of the current to pass through the water from one turn of the coil to another. No evidence of such an action having taken place was, however, observed at the conclusion of the tests.

An uniform temperature of the water in the calorimeter was secured by using two miniature screw-propellers of wood, which were constantly turned in the water during the experiments.

When everything was ready for the test the generator was run until the circuit was thoroughly heated, and its resistance remained constant.

The calorimeter was then thrown into the circuit and an equal resistance of circuit thrown out, so as not to alter the total resistance. At the end of the test the resistance was measured as soon as the circuit was broken and before the wires had cooled.

Data from this test.

Weight of calorimeter empty, 31 pounds.
Weight of calorimeter full, 58·25 pounds.
Weight of water in calorimeter, 27·25 pounds.
Range of temperature, = 91·2° = 68·6° = 22·6° Fahr.
Specific heat for above range, = 1·018.
Time of test, = 25 minutes.
Resistance of iron wires and calorimeter coil, = ·484 ohm.
This resistance and field in multiple are = ·475 ohm.
Total resistance of circuit, = ·475 × ·03 = ·505.
Resistance of calorimeter coil, = ·09 ohm.
Ratio of resistance of total circuit to resistance of calorimeter coil, $= \frac{\cdot 505}{\cdot 09} = 5{\cdot}61$.

Results.

Energy developed in calorimeter =

$$\frac{27{\cdot}21 \times 1{\cdot}018 \times 22{\cdot}6^\circ \times 772}{25} = 19330{\cdot}89 \text{ft.-lb. per minute.}$$

Total electrical energy developed in circuit,

$$19330{\cdot}89 \times 5{\cdot}61 = 108446{\cdot}28 \text{ft.-lb. per minute.}$$

Determination of the energy transmitted by the dynamometer in this test:

Speed of dynamometer, = 340 revs per min.
Sine of the angle of deflection, = ·36.

Therefore, indicated energy =

$$170{\cdot}5 \times {\cdot}36 \times 6{\cdot}28 \times 340 = 131056{\cdot}4 \text{ft.-lb. per min.}$$

Determination of the efficiency of generator from the above:

Energy consumed in turning armature in field of force =

$$131056{\cdot}4 \times {\cdot}858 = 112446 \text{ft.-lb. per min.}$$

$$\therefore \text{Efficiency} = \frac{108446{\cdot}28}{112446} = {\cdot}963.$$

That is, 96·3 per cent. of the power applied to the armature pulley appears as electrical energy in circuit and magnet coils.

Now, to find the "commercial efficiency," or the ratio of the mechanical energy required to drive the dynamo (including friction of armature bearings and agitation of air by armature) to the electrical energy which appears in external circuit, we have:—

Energy actually applied to armature pulley = total indicated energy less the friction of the dynamometer = 131056·4 × ·883 = 115722·8 ft.-lbs. per min. Of the total electrical energy generated there appeared in the armature

$$- 108446{\cdot}28 \times \frac{\cdot 03}{\cdot 505} = 6442{\cdot}35 \text{ ft.-lbs.}$$

And the electrical energy consumed in the field circuit, which appeared partly as heat and was partly used in magnetising the cores $= 108446{\cdot}28 \times \frac{505}{24{\cdot}51} = {\cdot}02 \times 108446{\cdot}28$ = 2168·92 ft.-lbs. per min.

Then the total internal work = 2168·92 + 6442·35 = 8611·27 ft.-lbs. per min.

Therefore the amount of energy appearing in external circuit = 108446·28 − 8611·27 = 99835·01 ft.-lbs. and the commercial efficiency $= \frac{99835{\cdot}01}{115722{\cdot}8} = {\cdot}866$.

Tests by Measurements of the Electromotive Force and Resistance.

In order to determine the electrical energy by this method, we first measured the electromotive force of the machine and the resistance of the line very accurately. From these data we found the current flowing by the formula $c = \frac{E}{R}$. Then, knowing the current, the electrical energy developed in external circuit is given by the following empirical formula $-c^2 R \times 44{\cdot}24$ = energy in ft. lbs. per min.

The electromotive force was measured between the binding posts of the generator by means of a condenser and a Thomson high resistance galvanometer.

The standard of electromotive force employed was the Latimer Clarke cell. Two of these cells were obtained newly made up from the Western Union Telegraph Company. They were allowed to charge a microfarad condenser, and the condenser was then discharged through the galvanometer. A number of experiments were made with these in order to determine accurately the deflection on the scale corresponding to a cell. This deflection is proportional to the current flowing through the galvanometer coils, and, consequently, of the charge held by the condenser, which depends upon the electromotive force of the charging cell.

The deflection corresponding to one cell was found to be exactly five divisions of the scale. Elliott Brothers' switch was used to connect the dynamo and galvanometer alternately with the condenser.

The connections were made as perfect as possible by amalgamation.

Data.

Capacity of condenser = ·05 microfarad. Deflection o

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galvanometer with condenser charged by cell = 5 divisions. Average deflection of galvanometer with condenser charged by dynamo = 103·5 divisions. Electromotive force of cell = 1·457 volts.

Therefore, 5 : 1·457 : : 103·5 : (x = 30·159 volts). Resistance of line while hot = ·431 ohm. Since the electromotive force was measured between the binding-posts the resistance of the armature was excluded.

Resistance of armature = ·03 ohm.

∴ Resistance between binding-posts = ·401 ohm.

Then $-c = \frac{E}{R}$.

$$c = \frac{30·159}{·401} = 75·2 \text{ webers.}$$

Energy developed in external circuit

$= c^2 R \times 44·24 = (75 : 2)^2 \times ·401 \times 44·24 = 100330·8$ft. lbs. per min.

Total electrical energy,

$$100330·8 \times \frac{·431}{·401} = 107352·95\text{ft. lbs. per min.}$$

Energy indicated by dynamometer,

Sine of mean deflection = ·352

Mean speed = 340 revs.

Indicated energy,

$170·5 \times ·352 \times 6·28 \times 340 = 128306$ft. lbs. per min.

Applied energy (equal total energy minus combined friction) = 128306 × ·868 = 110087 ft. lb.

Therefore, efficiency of machine $= \frac{107352·95}{110087} = ·975$ or 97·5 per cent. actually appeared as electrical energy in external and field circuits.

Determination of the commercial eff.

Energy actually applied to armature pulley—

$$128306 \times ·883 = 113294·19 \text{ ft. lb. per min.}$$

Of this there appeared in the armature—

$$107352·95 \times \frac{·03}{·431} = 7472·35 \text{ ft. lb. per min.}$$

And in the field circuit—

$$107352·95 \times \frac{·431'}{24·51} = 1887·76 \text{ ft. lb. per min.}$$

Therefore, total internal work =

$$7472·35 + 1887·76 = 9360·11 \text{ ft. lb. per min.}$$

Then there appeared in external circuit—

$$107352·95 - 9360·11 = 97992·84 \text{ ft. lb.}$$

And commercial efficiency =

$$\frac{97992·84}{113294·19} = ·864.$$

The resultant efficiency of the generator will be the mean of the two efficiencies as determined by the two methods, or;

Average efficiency = ·969,

Average commercial efficiency = ·865.

Efficiency of Motor.

In determining the efficiency of the motor as a machine for converting electrical energy into mechanical, we connected the generator and motor by heavy copper rods in order to reduce the loss of energy in the line to a minimum. A prony brake was applied to the pulley of the motor and the pressure of its arm upon a platform scale measured directly. This gave an accurate indication of the power of the motor.

To avoid heating of the brake by friction, it was arranged in such a manner that a stream of cold water entered it at the top, and after passing through it to the pulley, escaped by a hole in the bottom. In this way we were enabled to make runs of any length of time. Between the nuts which tightened the brake, and the brake itself, were placed thick rubber washers, which by their elasticity yielded to any inequality of motion, and kept the speed and corresponding pressure on the scale very constant.

By means of the brake we could apply variable loads and get various ratios between the speeds of the two machines.

The electrical energy entering the motor was controlled by altering the variable resistance in the field of the generator.

Although this alteration diminished the intensity of the magnetic field, the work done in the coils did not vary until after the third decimal place, so the commercial efficiency of the machine remained constant.

The conditions, however, having been altered, the results are not such as can be plotted in a curve.

It is to be remarked that in these experiments the machines which we used were so large that it was not possible to work them up to their full capacity, the dynamometer being unable to transmit sufficient power.

The results obtained are tabulated as follows:—

Dynamo.

No.	Speed.	Sine of deflection.	Indicated power in ft. lbs.	Per cent. applied to armature.	Actual energy applied to armature.	Com. effi.	Ft. lbs. current in external circuit.
1	405	·355	153945·6	·883	135928	·638	86717
2	405	·420	182132·8	·883	160820	·638	102603
3	405	·475	206983·6	·883	182763	·638	116000
4	405	·515	223329·5	·883	197200	·638	125813
5	405	·565	243060·6	·883	214620	·638	136927
6	405	·520	225497·8	·883	169910	·638	108402
7	405	·585	253685·0	·883	223995	·638	142905
8	405	·66	286208·8	·883	254921	·638	152638
9	405	·31	134431·4	·883	118701	·638	75730
10	405	·345	149609·1	·883	132104	·638	84279
11	405	·350	152777·3	·883	134895	·638	86059
12	405	·360	156113·9	·883	137847	·638	87941
13	405	·515	223329·5	·883	197200	·638	125823

Motor.

No.	Speed.	Weight.	Ft. lbs. given out by Motor.	Ft. lbs. of Current in External Circuit.	Efficiency of Motor.
1	932	2	29264·8	86717·0	·337
2	892	4	56017·6	102603·0	·545
3	860	6	81012·0	116000·8	·699
4	844	8	106006·4	125813·0	·842
5	800	10	125600·0	136927·0	·917
6	1042	4	65437·6	108402·0	·603
7	1021	6	96178·2	142905·0	·671
8	1185	4	74418·0	152638·9	·481
9	763	4	47916·4	75730·6	·633
10	717	6	67541·4	82279·8	·809
11	572	8	71843·2	86059·8	·834
12	564	8	70838·4	87941·9	·806
13	738	10	115866·0	125823·6	·921

No.	Work done by Motor.	Work absorbed by Generator.	Efficiency of Combination.
1	29264·8	135928	·214
2	56017·6	160820	·348
3	81012·0	182763	·443
4	106006·4	197200	·539
5	125600·0	214620	·580
6	65437·6	169910	·390
7	96178·2	223995	·429
8	74418·0	254921	·292
9	47916·4	118701	·403
10	67541·4	132104	·511
11	71843·2	134895	·532
12	70838·4	137847	·515
13	115866·	197200	·589

Efficiency of Motor.

The motor, as a machine for converting electrical energy

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into mechanical, seems to be excellently adapted to the purpose. The only point that admits of improvement is probably the resistance of the magnet coils, which should be higher in proportion to the resistance of the armature, thus taking less current to keep up the magnetic field.

Efficiency of the Combination.

It is when the generator and motor are coupled together that the efficiency of the whole falls, as is shown by the tables, to such a low percentage.

The reason for this, however, and the means of remedying it seem obvious.

By one of the fundamental laws of electricity, we know that the work done in any portion of an electric circuit is directly proportional to its resistance.

In the case of the two machines coupled, as in the above series of experiments, the resistance of each was very low and equal, while the resistance of the line was practically nothing.

Under these conditions, nearly half the work must necessarily be done in the generator, and the results verified this law.

In order then to increase the efficiency of the combination, more work proportionally must be done in the motor and less in the generator. To accomplish this, we find by applying the above rule that one of two things may be done—we may either decrease the resistance of the generator or increase the resistance of the motor. In practice, a compromise would probably be made, that is, the generator armature would have its resistance reduced, and the motor have the resistance of its armature raised sufficiently to cause nearly all the work to be done in the motor.

This applies to a single motor.

Where several motors were supplied with current from a single machine they would probably be arranged in "multiple arc," and be of such a resistance that they would take only a certain amount of current, and, when coupled up with the generator, their resulting resistance would be the same as would be given to a single motor doing the combined work of all.

In this way each machine does in a measure induce its own current and controls the current generated, so that if only one motor is running, the current generated is only sufficient for it, and as each one is put in circuit the current increases in a ratio which just keeps each motor supplied with the proper amount of current.

When by a course of experiment the proper ratio of resistances shall have been determined, there seems to be no reason why the combined efficiency should be below 80 per cent.

THE ACTION OF THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Mr. Smillie's suggestion (p. 208) that the resistance of a transmitter in vacuo is diminished by extracting the air from the pores of the carbon is fallacious, for the reason that the carbon forms a continuous structure, and the pores formed by this structure might be filled with paraffin without altering the resistance, provided a good surface contact is made by dissolving the paraffin on the outside, or scraping it off. He further says he cannot conceive two bodies in contact and a third between. Certainly not. But I pointed out that a loose contact may not be a contact at all, and this conception is, I think, easily within the reach of probability.

Truly, the admission of an intervening air space is "favourable" to the arc theory, but the arc is not a necessary consequence. But supposing by a proper increase of pressure on the "loose" contact we produce a "real" contact, this would not do away with the air layer when the contact changes under the vibration of the voice.

I hope soon to continue the experiments with a Sprengel or Geissler pump, which thus far I was not fortunate enough to have at my disposal, and I have no doubt that in "high" vacuo, where the condensed air will disappear from the carbon surface, the character of the sound produced by vibrating the contact will be similar to a true "metallic" contact.

In the meantime the practical telephonist will be careful to avoid Professor Blyth's arc transmission, and use as hard a carbon and as low an electromotive force as possible.—Yours, &c., E. BERLINER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: If Mr. Smillie will be good enough to read my letter on p. 230 a little more carefully, he will see that I simply intend to point out that there must be a variation of pressure between the electrodes when the transmitter is in action, and that this variation is sufficient to account for all the results. On p. 109 Mr. Smillie sets forth the theory that the action is due to the variable resistance of carbon *per se*. Now, it has been shown over and over again that this is not so, and that the variation of current arises from a variation of conductivity between the electrodes consequent upon the variation of the closeness or the pressure of contact. In not a single one of his experiments has Mr. Smillie attempted, so far as I can ascertain, to eliminate this effect. To prove his case, he should show the behaviour of a block of carbon coppered on opposite sides, and having the circuit wires soldered to the copper, and then, as he objects to vices and steam hammers, he might tickle it with the bristle, or blow upon it with the bellows.

Since he, with considerable fairness, reproduces my reasoning, and agrees with the conclusions I obviously indicated, I fail to see how I am hoist with my own petard. I merely take one objection, and that is to the use of the words "maintenance of a closed contact;" for "contact," I would substitute "circuit." Mr. Smillie set forth with the theory already alluded to, and all I desired to do was to show that in the experiments conducted by him the essential condition of an absolutely closed circuit with no possibility of a variation of resistance save within the carbon itself, which is required to prove his case, was conspicuously ignored.

Will he kindly explain how or when he tried to induce me to sign my name that he expresses sorrow for his failure in obtaining. If the revelation will tend to his happiness, or add force to the argument on either side, it is heartily at his command. I merely consult my personal feelings in employing my initials only.—Yours, &c., W. E. H.

NEW TELEPHONE SWITCH BELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 10th I notice a sketch and description of a new switch bell, the chief feature of which appears to me to be the arrangements of the circuits through the switch, *i.e.*, instead of the movement of the telephone hook working as a switch, to put in circuit the bell or telephone as required, it works as a shunt to short-circuit that portion of the apparatus not required, excepting the double contact springs. There seems to be no other novelty in the bell than that one of the transmitter screws is dispensed with. The bell is stated to have been designed by Mr. Volk for Mr. Haworth. If this is so it is very singular indeed, for I have now in my possession a bell made some ten months ago from drawings and sketches supplied to me by Mr. Haworth, and this bell is, in every particular, similar to the one illustrated in your valuable paper. There is no doubt whatever that the credit of designing the bell belongs entirely to Mr. Haworth. Your readers will, probably, notice that one of the stops for the telephone hook is put in the wrong place.—Yours, &c., W. BANKS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you please allow me to draw your attention to the following improvements in the bell (illustrated and described on page 299, Feb. 10), due to Mr. Haworth, and not myself:—1. The use of screw terminals instead of milled heads, and placing the same at the bottom of the bell instead of at the top. 2. Abolishing one of the connections between transmitter and bell. 3. The arrangement of the circuits so that the telephone and bell circuits are cut out by means of a shunt instead of the usual make and break. 4. The special method of reversing the current by means of the springs s, s', s''.

The stop under the hook lever should have been shown lower. As now shown there would be no room for the lever to travel.—Yours, &c., M. VOLK.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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ANSWERS TO CORRESPONDENTS.

J. D. H. Roubaix.—Vol. IX. dates from May 13 to November 11, 1882. We published a supplement, containing "Hints for Electric Light Engineers," with our issue of January 7, 1882, in pocket form. The publisher has some on hand still; the price is one penny. We intend to publish other supplements from time to time in continuation of the above.

P. N., Haverstock Hill.—The pocket book is not yet completed. We intend publishing additional supplements in continuation of No. 1.

P. Howell.—The works you mention are not printed in English. The most important results contained in M. Deprez's papers have been given from time to time in our columns.

J. M., Jersey.—It would be made an action for libel if we were to answer your question fully.. Our advice would be, have nothing to do with concessions in any shape or form.

THE TELEPHONE APPEAL CASE.

The contest between the several claimants for patent rights in telephones has been renewed so frequently, both in this country and in America, that hardly anything new remains now to be said about it. Its reappearance for nearly a fortnight in the English Court of Appeal during the concluding days of last month and the opening days of the present was noteworthy only in the circumstance that the issues had been narrowed since it came before the Court below, and the claims more strictly defined. For one thing Mr. Edison had eliminated the phonograph from his original specification, the English law permitting that course to be taken where an inventor has inadvertently gone beyond the range of what he finally determines to claim. The Edison carbon transmitter was thus left face to face with the Hunnings carbon transmitter; and the Court below having had no hesitation in deciding not merely that Mr. Edison's invention had priority but that Mr. Hunnings's was an infringement of it, the decision remained unchallenged. In the opinion of many people the invention and publication of the microphone by Professor Hughes ought to invalidate the claims of both these parties—at all events in England; but we can quite understand why neither of them set up a plea which, if it destroyed the pretensions of his rival, would be equally destructive to his own. When the two Foxes quarrelled over the Goose they studiously avoided all mention of the Farmer.

We cannot dismiss this part of the case, however, without once more adverting to the anomalous position in which the decision, just and equitable though it be, has landed us. Mr. Hunnings's transmitter is acknowledged to be a very good one; its predecessor is said to be not so good, and in several respects not so serviceable for everyday use. Be this as it may, one thing appears to be certain, that whatever its superiority might have been, the later invention would have been condemned, and the public consequently deprived of its use, because somebody else had contrived an earlier and similar, though less useful, instrument. This is a case, it seems to us, where patent laws, while very properly protecting the rights of inventors, tend to discourage the efforts of improvers, and are thus not conducive to the public interests. It is nowhere suggested that the Hunnings transmitter is a wilful piracy, or even a colourable imitation; on the contrary, some eminent experts have testified to its being a new and independent invention, besides being one of considerable practical utility. By this judgment it is, we suppose, now shut out of the market, and the public consequently compelled to use another invention, whether they like it or not. Probably the public, if they had any voice in the matter, would disclaim any wish to deprive the first inventor of his rights; but, in public estimation, rights are simply another word for merits, and on their merits respectively the two inventions—so the public would say—ought to stand.

Having said this much on behalf of the improver, and in the interests of the public, we feel ourselves at liberty to be equally candid in respect to original inventors. As regards the main invention involved in this appeal, that is to say the telephone invented by Mr. Bell, we hold that if he had been deprived of his claim on the strength of the plea set up against it the result would have been most deplorable—deplorable not merely in its immediate consequences to the inventor, but to all inventors ever afterwards. It would have shown that no invention, however valuable or however original, is safe from assault on any technical plea that happens to come handy. The one selected in

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the present trial was that Professor Bell had published his invention before he patented it; and the law of this country is such that only by a quite providential accident did the famous inventor escape the consequences of his indiscretion. The telephone he sent to Sir W. Thomson fortunately would not speak, and, either by accident or design, arrived in a condition so that nobody could make it speak. True, the experts on the other side are now able to persuade it to behave something like the perfect instrument, but this only *after* they have learnt what the perfect thing should be from the very patent which they seek to upset. A flute is no use, as one of the judges remarked, unless you know how it should be played, nor, we may add, if the holes are stopped up, or both ends knocked out.

As to the other pleas urged against Bell's patent, if they are guiltless of mere legal technicality they are hardly less free from the charge of disingenuousness. It is true that Reis and Borseul, and Page, and Varley, and Gray had all been at work in the same field of discovery as Graham Bell, and most of them before his time. If he had independently discovered something which they had already found out it would be much to his credit, but not in the least to his profit. But the fact is he made not only an independent but a totally new discovery. It is by no means certain that the other investigators were even aiming at the result he aimed at—telegraphic signalling being far away different from vocal signalling, and, on the other hand, it is perfectly certain none of them had realised the one condition upon which alone vocal signalling could be accomplished. Here again the instruments contrived by Bell's competitors, notably that of Reis, in the hands of experts, can now be made to speak like a telephone, or, at all events, some people are obliging enough to fancy that it can; but in the hands of Reis it could not articulate, and on the principle of construction adopted by him it never would have articulated, except by accident. That accident did not occur, or, if it did, it threw no light on the cause of its occurrence, and the true conditions of success in vocal telephony remained as dark as ever. To Professor Bell belongs the high, and, indeed, rare merit of starting on fresh lines, pursuing his object on scientific principles, and finally grasping the very thing he was in search of. Having done all this, and having, moreover, done it before anybody else had so much as dreamt of its being done in *that* way, it would be a flagrant injustice to deprive him of any of the fruits of his labour on the plea that *sounds* had already been transmitted by electricity, still less on that of his having sent a crude pattern of his invention in a friendly way to this country before taking legal means of securing it from piracy there.

Electric Lighting in the Mersey Tunnel.—Some time since these extensive works were lit up with incandescent lamps. These have now been supplemented by twenty-four Brush arc lights driven by two Brush dynamos. Twelve of their arc lamps are now being used in the tunnel at the Birkenhead side of the river with good effect, and have proved of great benefit to the men working in the tunnel. The installation at the Liverpool side is now nearly complete. The lights will be brought into use next week. The whole work has been placed in the hands of the Hammond Electric Light and Power Supply Company, Liverpool, and has been efficiently carried out under the superintendence of Mr. J. Shaw, district manager.

Electric Lighting in Italy.—It is said that the town of Alcamo has concluded a contract with a company called the Société Industrielle Franco-Italienne for the lighting of its streets by incandescent lamps.

The Edison Light at the Holborn Restaurant.

On Thursday evening, Feb. 15, we had the pleasure of being present at what might be termed the inaugural dinner of the Edison Installation at the Holborn Restaurant. Mr. Arnold White, the secretary of the company, presided, having as his *vis-à-vis* Dr. Fleming. The guests were, as far as we could gather, principally those employed upon the special installation. During the evening Mr. White referred to his recent visit to Mr. Edison, and to the improvements in the electric light apparatus that indefatigable worker had made during the last three or four months—improvements which it was hoped would place them well to the fore, in spite of any and every competitor. Dr. Fleming referred to the valuable assistance and suggestions received from Dr. Hopkinson, whose ability and energy were so highly appreciated by all who came into contact with him, and especially those present, who knew how much was due to him for those suggestions which, being well carried out, made their work so successful. We were especially struck, as we always are when brought into contact with representatives of Mr. Edison, with the individual belief in the powers of Mr. Edison, in his ability not only to give them equally good, but better lamps and machines than those of other inventors. We like this spirit; we like to see men with faith in the thinkers whose thoughts and realisations have to be carried into practice by them. We do not say that Mr. Edison is the only inventor whose assistants have such a feeling towards him; we could point to other men and other minds for similar examples, but we recognise the fact that those brought into contact with Edison do throw their hearts into their work, and the result is seen in the many successes which have been achieved with his system. The English Company is to be congratulated upon the success of the installation at the Holborn, and we trust it is but the first of a large number of similar installations that we shall have to record.

The Holborn Restaurant is so well known to those who live in or frequently visit London, being one of the most popular establishments in London, that we need not refer to it at length. During the last year it has been undergoing extensive alterations, which it is hoped will be finished in a few weeks, when some of the finest rooms in the metropolis will be at the command of the public. It has been decided as one of the improvements to substitute the electric light throughout the premises for gas, and this work was placed in the hands of the Edison Company. The necessary plant for 500 sixteen candle lamps has been placed in position at 10, Little Queen-street, a building adjoining the restaurant. The plant consists of two K or 250 light dynamos, driven by two of Ransome's semi-portable engines specially built for electric light work, each of sixteen horse-power nominal, and fitted with automatic governors. From the generating station the current is conveyed underground by the system of leads designed by Mr. Edison, through the churchyard of Trinity Church to the building to be lighted. The whole of the internal fittings are not yet complete, owing to the fact that a portion only of the building is undergoing alteration at one time. When the whole is complete, we hope to be able to give a plan of the circuits, &c. The rooms completed are those known as the Prince's and the Colonel's room. The dinner we have briefly referred to above was held in the Prince's room, which we thought well lighted with 18 A (16 candle) lamps. We do not believe in overlighting any more than we believe in underlighting, though the latter may be tolerated, while the former is dangerous. We closely watched the lamps for several hours, and they gave an admirably steady light of, we should judge, quite 16 candles per lamp. We felt more strongly than ever that the incandescent light is as superior to gas as gas is to a tallow candle, and that it is a mere question of time for the one to be adopted in place of the other. The number of lamps to be sustained by the plant is about 650, partly A and partly B (eight candle) lamps. The remainder of the lamps required for the building will be supplied from the station at 204, High-holborn. The fixtures, which, so far as we could judge, are elegant and tasteful, have been designed and supplied by Messrs. B. Verity and Sons, of King-street, Covent Garden.

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STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

[*These answers are intended to guide, to give information and references, to put the student in the way of getting information, and* NOT *to give the exact answers that should be written in an examination.*]

The solutions in this number are solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. RIMINGTON, ESQ. (School of Electrical Engineering), 12, Princes-street, Regent-street.

15. Describe methods of ascertaining the exact connection between the speed of the generator, the speed of the motor, the resistances of the machines and of the connecting wires with the efficiency obtained in the electric transmission of power.

Ans. If E be the total E.M.F. of the generator, and E_1 be the total back E.M.F. of the motor, that is to say, the E.M.F. produced by the rotation of the motor, and which always opposes that produced by the generator, and ΣR be the total resistance in circuit, current $= \frac{E - E_1}{\Sigma R}$.

Horse-power applied to drive generator

$$= \text{H.-P.} = \frac{EC}{746} = \frac{E(E - E_1)}{746 \Sigma R}.$$

Horse-power expended electrically by the motor

$$= h.p. = \frac{E_1 C}{746} = \frac{E_1 (E - E_1)}{746 \Sigma R}.$$

Now, efficiency is the ratio of the horse-power put into the generator to the horse-power given out by the motor

$$= \frac{h.p.}{\text{H.-P.}}$$

$$= \frac{\frac{E_1 (E - E_1)}{746 \Sigma R}}{\frac{E (E - E_1)}{746 \Sigma R}} = \frac{E_1}{E}.$$

When current is constant E.M.F. varies as speed. Let S be speed of generator and s be speed of motor. According to Professor Lodge

$$\text{E.M.F.} = \frac{K S \rho \phi C}{2}$$

where K is a constant depending on the size and arrangement of the armature of the machine; S = speed; ρ = internal resistance of generator; and ϕ is a function determined by the size, shape, and quality of iron of the dynamo.

In a dynamo to obtain the maximum efficiency *per se* the resistances of the armature and field-magnets should be equal. If this be not the case the above equation would be written

$$\text{E.M.F.} = K S \sqrt{a b}\, \phi C.$$

Now, efficiency $= \frac{h.p.}{\text{H.-P.}} = \frac{E_1}{E} = \frac{\frac{K_1 s \rho_1 \phi_1 C}{2}}{\frac{K S \rho \phi C}{2}} = \phi_1 \frac{K_1 s \rho_1 \phi_1}{K S \rho \phi}$.

If the two dynanos are exactly similar efficiency $= \frac{s}{S}$.

16. Given the resistance of the generator and motor, and of the line wire per mile, calculate a formula which tells the amount of power lost from the heating of the wires when a certain amount of power is transmitted over a certain number of miles. Apply your formula to several numerical cases.

Ans. The heating of the wires entirely depends on the amount of current passing, and is equal to $C^2 R$.

The amount of current passing depends on the relation between the E.M.F. of the generator and the opposing E.M.F. of the motor. The more nearly the latter approaches the former, the less the current passing, the less the total power in the whole circuit, but the greater the ratio of the power transmitted to the total power. From the resistance of the wire on the machines and that of the line wire, it is, therefore, impossible to calculate the required formula. If, however, some other datum, such as the E.M.F. of the generator, the back E.M.F. of the motor or the current, be given, we can obtain this formula.

Let us first suppose that the current is given, then the power absorbed in heating the wires $= \frac{C^2 R}{746}$ h.-p., where R is the resistance of the generator, the line wire, and the motor.

Next, let us suppose the back E.M.F. of the motor to be given. Call this e.

Let w be the power transmitted expressed in horse-power, ρ = resistance of generator, ρ_1 = that of motor, r = resistance of line wire per mile, and n = number of miles of line wire.

Call the sum of these resistances R, so that

$$R = \rho + nr + \rho_1.$$

Let E = E.M.F. of generator, an unknown quantity at present, and W = power put into the generator, also unknown at present.

Then we have the following two equations:—

$$\left.\begin{aligned} \frac{w}{W} &= \frac{e}{E} \quad (1.) \\ W &= \frac{E(E - e)}{746 R} \quad (2.) \end{aligned}\right\}$$

From (1.)

$$W = \frac{w E}{e}$$

$$\therefore \frac{w}{e} = \frac{E(E - e)}{746 R}$$

$$\frac{w}{e} = \frac{E - e}{746 R}$$

$$E e - e^2 = 746 w R$$

$$E = \frac{746 w R + e^2}{e}$$

$$\therefore W = \frac{\frac{w (746 w R + e^2)}{e}}{e} = \frac{w (746 w R + e^2)}{e^2}$$

But power absorbed in heating the wires is the difference between the power put into the generator and that given out by the motor. $= W - w$.

$$\therefore H = W - w = \frac{w (746 w R + e^2)}{e^2} - w;$$

$$= \frac{w (746 w R + e^2 - e^2)}{e^2} = \frac{746 w^2 R}{e^2};$$

$$= \frac{746 w^2 (\rho + nr + \rho_1)}{e^2}.$$

Again, suppose we know E and do not know e, we have, as before,

$$\frac{w}{e} = \frac{E - e}{746 R},$$

$$e(e - E) = -746 w R,$$

$$e^2 - E e + \left(\frac{E}{2}\right)^2 = \frac{E^2 - 2984 w R}{4},$$

$$e - \frac{E}{2} = \frac{\pm \sqrt{E^2 - 2984 w R}}{2},$$

$$e = \frac{E \pm \sqrt{E^2 - 2984 w R}}{2},$$

$$\therefore W = \frac{2 w E}{E \pm \sqrt{E^2 - 2984 w R}},$$

$$\text{and } W - w = \frac{w (2E - E \mp \sqrt{E^2 - 2984 w R})}{E \pm \sqrt{E^2 - 2984 w R}}$$

$$= w \cdot \frac{E \pm \sqrt{E^2 - 2984 w R}}{E \pm \sqrt{E^2 - 2984 w R}}$$

Multiplying numerator and denominator by

$$E \mp \sqrt{E^2 - 2984 w R}$$

we obtain

$$H = \frac{w (E \mp \sqrt{E^2 - 2984 w R})^2}{E^2 - E^2 + 2984 w R}$$

$$= \frac{(E \mp \sqrt{E^2 - 2984 w R})^2}{2984}$$

$$= \frac{E^2 + 1492 w (\rho + nr + \rho_1) \mp E \sqrt{E^2 - 2984 w (\rho + nr + \rho_1)}}{1492 (\rho + nr + \rho_1)}.$$

In practice the minus sign will be the one employed in the expression

$$\mp \sqrt{E^2 - 2984 w R}.$$

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SELF-REGULATING DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of Jan. 6 you speak of "taking some members of the technical press into confidence, and put out of question once and for all claims to priority by a suitably worded paragraph which records but does not enter into details." Your observation may be a very just one, but it is open to several objections. There are, unfortunately, in the world a great many people who claim for their inventions what is not a peculiarity of their invention particularly, yet who will say when they hear that So-and-so does with his invention such-and-such a thing, "Oh, mine does all that." But it does not. So when, after previously indicating the advantages of your invention, you come to bring it before the public, it is really astonishing to find how many old inventions are claimed to have that peculiarity. I will trouble you with an instance. We all know that it is practically impossible to burn an arc lamp and an incandescent lamp together on a simple shunt-circuit machine unless there is very wasteful resistance in the arc lamp circuit; at least, we all ought to know it, because the reason is simple enough, and can be easily seen to be that the very small external resistance during contact of the carbons reduces the potential difference at the ends of the shunt-coil to too low an amount to charge the magnets. Yet I have thrice this week been told that the "combination" system had no advantage in this respect. In the last case I insisted on seeing so extraordinary an improvement on common sense, and had shown to me a merely ordinary series dynamo as "self-regulating." Verily, the world—or some of it—has assurance. I think, however, I will turn purchaser of one of these pseudo-inventions, and having effected my purchase under strict agreement and otherwise unconditionally, I will prosecute my vendor for obtaining money under false pretences.

Another reason is that in some countries such a publication would invalidate one's application for a patent. Your correspondent, Mr. Menges, seems to intimate that this is the case in Germany. *How much better would it be if priority of publication in scientific journals gave prior patent right!* As it does *not*, but unfortunately *invalidates* that right (as has been contested in the telephone case, for example), the choice lies between fame and bread and cheese. Many inventors are like me, they prefer the latter.

Yet another reason is illustrated in the letter of your correspondent Mr. Menges. Appearing at the close of a discussion as to priority it would indicate, without giving any date, a desire to claim priority to my patent of 1881 for the "combination" shunt and main-circuit magnet system of winding dynamos, and to endeavour to base a new invention on the place of connection of the shunt wires. Don't you think that when communications are made *in confidence* they should be backed up by some statement as to date, and that the editor receiving the communication should, as in the present instance, intimate the date? Speaking as having been an editor myself, I would do so affirmatively.

Your correspondent, Mr. Menges, appears to claim the insertion of the shunt-circuit at the machine terminals; perhaps some one will be kind enough to patent their insertion on the nth convolution of the main-circuit magnet. The only sensible suggestion I have seen is that described by Professor Sylvanus Thompson in his Cantor lecture, and termed the "Long-Shunt" combination system, one that I use under some arrangements of external circuit, and used in the autumn of 1880.

I think I have given you three fair reasons for secretiveness in inventing, and I fear that these reasons will hold good until you can induce the authorities to alter their dictum that priority shall depend on date of patent and not of publication in a journal of known issue. But why not agitate for this alteration, one that would give every workman far greater protection than "provisional specifications" of any kind?—Yours, &c., PAGET HIGGS.

ERRATUM.—On page 329 of our last issue we attributed our abstract of the report of an interview with Mr. Edison to the *New York Sunday Herald*. It should have been the *Boston Sunday Herald*. Last week's abstract dealt with Mr. Edison's opinion on storage batteries. In next week's issue we shall give his opinion on electric lighting.

CANTOR LECTURES.*

DYNAMO-ELECTRIC MACHINERY.

BY PROFESSOR SILVANUS P. THOMPSON, B.A., D.SC., M.S.T.E.

Lecture III. (concluded).—The Dynamo as a Motor.

(CONCLUDED FROM PAGE 329.)

It is, of course, possible to use as a motor any direct current dynamo, whether the field-magnets be series-wound, shunt-wound, separately excited, or permanently magnetised. There is this curious point of difference in different cases. Suppose the dynamo to be arranged so as to work as a generator, and then to be supplied with currents from an exterior source, to make it work as a motor. If the dynamo is series-wound, it will run the reverse way (or against its brushes), no matter which way the currents run through it. If the dynamo be shunt-wound, it will run with its brushes, whichever direction the current runs through it. The direction of rotation taken by the separately-excited and the magneto machine will also be with the brushes, if the current is in the right direction, through the armature. These points have to be taken into account in any attempt to combine the different systems.

If we attempt to apply to motors rules and suggestions, such as these applied to generators in the first of these lectures, we shall find that, whilst some of them apply directly, others are singularly in contrast. For example, we found it advisable, for the sake of steadying the currents in generators, to use large and long field-magnets with plenty of iron, and with heavy pole pieces. In the case of motors, there is no such necessity laid upon us; for we want here to produce a uniform steady rotation. Now, even if the impulses be intermittent, the mechanical inertia of the moving parts will steady the motion. Electric currents have no such inertia (except in so far as the self-induction in a circuit exerts an influence like that of inertia), and hence the precautions for generators. In the case of generators, we found that, to produce steady currents, we had to multiply coils on the armature in many separate paths, grouped round a ring or a drum, involving a complicated winding and a collecting apparatus, consisting of many segments. In motors no such necessity exists, provided only we arrange the coils that there shall be no dead points. I do not say that, for large motors, it may not be advisable to multiply the paths and segments for other reasons—as, for example, to obviate sparking at the collectors—but, for securing steady running, the inertia of the moving parts spares us—at any rate, in small machines—the complication of parts which was expedient in the generator. Some of the most successful of the little motors that have recently appeared—those, for example, of Deprez, Trouvé, and Griscom—have for their armatures the simple old shuttle-wound Siemens armature of 1856, and in these motors, of course, there is the disadvantage of dead-points to take into account. Deprez, in his first motors, placed this armature longitudinally between the poles of a horse-shoe magnet, with the axis parallel to the limbs. He has also constructed motors with two such armatures on one spindle, one of the coils being 90deg. in advance of the other, so that while one was at the dead point, the other should be in full action. The same suggestion has been carried out in Akester's motor. Trouvé has tried to get over the dead-points, by utilising the method of oblique approach mentioned earlier in my lecture. The Griscom motor, which has little copper rollers as commutator brushes, has, for field-magnets, a compact tubular electro-magnet wound in series with the armature. It has the disadvantage of dead-points. There is, in all these motors, the disadvantage that at every half-revolution the magnetism of the armature core is reversed; and as in all these forms this core is of solid iron, there must be waste by heating in the cores. In fact, to the rotating armatures of motors, as to those of generators, apply all the rules about slitting to get rid of induced eddy-currents, avoiding idle coils and useless resistances, &c. The rules about proper pole-pieces, adjustable brushes, multiplication of contacts, also are mostly applicable to motors as well as to generators.

In order to meet the case of a handy and reliable motor, I have designed a machine, the smallest size of which is on the table before you. The field-magnets, which also constitute the bed-plate of the motor, are of malleable cast iron, of a form that can be cast in one, or at most two, pieces. The form of them is that of a Joule's magnet, with large pole-pieces, and wound with coils, arranged partly in series, partly as a shunt, in certain proportions, so as to give me a constant velocity when worked with an external electromotive force of a certain number of volts.

As an armature, I employ a form which, I think, unites simplicity with efficiency for the end desired. I do not want dead

* Reprinted from the *Journal of the Society of Arts*.

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points, and yet I do not want to have a complicated armature. I have, therefore, modified the old Siemens armature by embedding, as it were, one of these shuttle-shaped coils within another, at right angles to one another. And having duplicated the coils, I must, of course, duplicate the segments of the commutator, which, therefore, becomes either a four-part collector, or else a double collar, according to circumstances. There are no solid iron parts in the armature, but the cores are made of thin pieces of sheet iron, stamped out and strung together. Of the efficiency of this little motor you were witnesses a little while ago, when I employed it in the experiment with the galvanometer.

There are here on the table two other forms of moter, one of which is the design of Mr. A. Reckenzaun, C.E., and which is interesting because its armature, though a drum-armature in form, in reality consists of independent coils, connected, like those of the Brush dynamo, to separate commutators. There are, in fact, four commutators grouped as two twos, and two pairs of brushes in contact with them.

The other motor is one of the pattern invented by De Meritens, who employs a ring-armature very like that of Gramme, but places it between very compact and light field-magnets, which form a framework to the machine. There is one point about this machine of great interest, which is, however, a later addition. It is provided with a reversing gear, which, when I move the handle, reverses the direction in which it runs. This gear, which is the invention of Mr. Reckenzaun (to whom I am indebted for the loan of this motor) is shown in Fig. 38. In it there are two pairs of brushes; the two upper are fixed to a common brush-

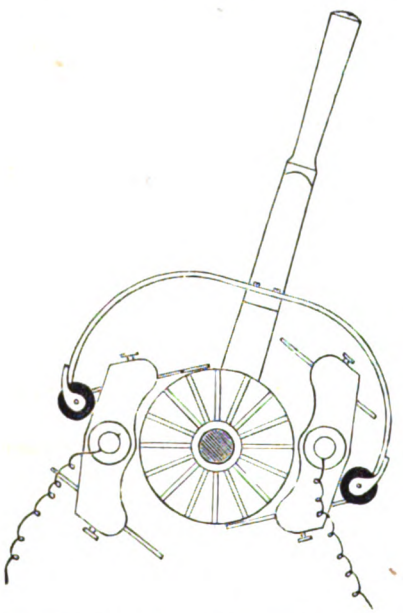

FIG. 38.—Reckenzaun's Reversing Gear.

holder, which turns on a pivot, and can be tilted by pressing a lever handle to right or to left. The two lower brushes are also fixed to a holder. Against each brush-holder presses a little ebonite roller, at the end of a bent steel spring, fixed at its middle to the handle. The result of this arrangement is that, by moving the lever, the brushes can be made to give a lead in either direction, and so starting the motor rotating in either direction. Such a reversing gear is obviously a most essential adjunct for industrial applications of motors, and, if the difficulties of sparking at the brushes, caused by the sudden removals of them from the collector, be obviated, must prove much better than any mechanical device to reverse the motion, by transferring it from the axle of the motor through a train of gearing to some other axle. One great advantage of electric motors is, that they can be so easily fixed directly on the spindle of the machine they are to drive; an advantage not lightly to be thrown away.

There is, indeed, an immense field for useful industrial application of electric motors, so soon as we once have at our disposal regular town supplies of electric currents. Already we have got the little motors of Griscom, Howe, and others, adapted to work sewing machines and instruments requiring very small power. Larger motors, for driving lathes and heavier machinery, though not yet much known to the public, are in the market. Messrs. Siemens have brought out an electric lift or elevator,* in which a small dynamo, itself running very quickly, drives an endless screw, and communicates a slow, but powerful, motion to a drum, on which the hauling chain is wound. If town-supplies of electricity were accomplished facts, such lifts will be multiplied. Indeed, there are very many purposes for which hydraulic power is used, for which electric power might be advantageously substituted. The electric railway, dimly foreshadowed by George Little, in 1844, when he patented an "electro-locomotive," has become an established fact. From the electric railway first established in Berlin, in 1880, by Siemens and Halske, we already have had the further developments of the electric tramway in Paris, and the experimental electric railway at the Crystal Palace. Edison has constructed an electric railway at Menlo Park, and built electric locomotives to ply upon it. Nor must I omit to mention how, in the bleaching fields of France, an electric tramway does most satisfactory duty; nor how, finally, in the sister isle, at the Giant's Causeway, Messrs. Siemens Brothers have established a line of electric railway, which is now actually in operation.

Latest of all the applications of the dynamo as a motor is that of electric navigation. Jacobi, as we know, fitted up, in 1838, an electric paddle boat, which he propelled on the Neva, first with Daniell's and afterwards with Grove's cells, and was even able, when he used 128 large cells, to carry fourteen persons against the stream, at a speed of about 1¼ miles per hour.

M. Trouvé, of Paris, was the next to apply electric power, in the shape of Planté's accumulators, to a pleasure boat, with which he navigated the Seine. But M. Trouvé has more recently abandoned storage cells, and has returned to the use of a bichromate battery, wherewith to drive the little boats, which he fits up with his little motors, mounted upon the top of the rudder, and turning a light screw-propeller by a driving belt, which passes down behind the rudder into the water.

Still more recent is the electric launch which made its trial trip on the Thames* last September. This is an iron boat twenty-five feet long, fitted with a screw, and able to carry twelve persons while running against the tide, at a pace of eight miles an hour. No existing motor of requisite power having yet been made of a form convenient to place directly upon the axis of the propeller, the expedient has, in this case, been resorted to of driving the screw by belts from an overhead counter-shaft, which receives its motion from two small Siemens dynamos placed below. Each of these dynamos has been provided by Mr. Reckenzaun, who designed the fittings of the launch with reversing gear like that shown in Fig. 38. The current which actuates these dynamos is derived from forty-five accumulators of the Sellon-Volckmar type, which are charged while the launch lies at its moorings. Though this is a great step in electric navigation, I venture to believe that it is yet but a beginning of greater things. As with steamboats, so with electric boats, we shall find that we begin with small experimental attempts, and increase in size as experience dictates. It is but a few days since I was reading in an old volume of the *Philosopoical Magazine* for the year 1801 of Symington's early little steamboat—the forerunner both of Fulton's and of Bell's—and the writer of the article hardly dared to think of this as more than an ingenious experiment, and doubted whether large vessels could ever be practically driven by steam. When I read this curious narrative, I bethought me of the trial trip of the little launch "Electricity," and began to think that I was not so very hopelessly wrong, when I wrote in September last, "Who shall say to what proportions this latest application may not attain in the next decade?"† Could we look forward, and see with our eyes to-night the electric boats of fifty years hence, we should not, perhaps, be more surprised than those who beheld the first rude steamboat would be, if they could now rise from their graves to behold the great ocean-going steamships of to-day. Indeed, when I look around and see so many opportunities for the future application of electric motive power, so many instances in which the dynamo would supply a welcome and economical‡

* Dr. Hopkinson has also invented an electric lift, in which the armature of the motor, running at a high speed, works the chain of the lift by a train of toothed wheels, which reduce the speed. This elevator was shown in operation at the Paris Exposition of 1881.

* In 1856, Mr. G. E. Dering constructed, at Messrs. Searle's, an electric boat worked by a motor, in which the rotation was effected by magnets arranged within coils, like galvanometer needles, and acted on successively by currents from a battery. It succeeded, I am informed, in making headway, though at small speed, against the tide at its swiftest.

† It is well known that a no less authority than Dr. Lardner publicly pronounced it impossible for any steamboat ever to carry coals enough to enable her to cross the Atlantic. It is also recorded that a very eminent public man offered to swallow the boilers of the first steamboat that should succeed in crossing the Atlantic. But he would be a bold man who would nowadays promise to swallow the accumulators or the dynamos of the first electric boat that shall successfully make the same trip across the water.

‡ As to the economy of electric motive power, I may, perhaps, be allowed to quote a passage from a recent lecture of my own in Bristol, in which a concrete case is presented:—"When it is possible thus to obtain power by merely turning on a tap, there will be an enormous impetus to all kinds of small machinery. Motors to work sewing-machines already

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means of doing that which is now done by less advantageous means, I begin to wonder why we do not establish central supplies of electric currents for this purpose, which is surely as important as electric lighting. Here we have the possibility of introducing machinery that is portable and light, giving us power without the inconveniences and risks hitherto attending the employment of power. Surely there must be many workshops in every town where the owner would be glad of having power without the trouble and danger of a furnace, boiler, and steam-engine, or even of a gas-engine, in his place; where a boiler cannot be put for want of space, and where a steam-pipe cannot be carried because of the inevitable condensation. So thoroughly am I convinced of the great future that lies before dynamo-electric machinery, from this point of view, that I am disposed to think electric lighting a very small item by comparison.* When once we get a proper system arranged for the general distribution of electric currents in a regular town supply, we shall begin to realise the hundreds of ways as yet undreamed of in which electricity may be utilised to meet our wants, and to subserve the ends of civilisation.

ON ELECTRIC LIGHTING FOR WORKSHOPS AND LARGE SPACES.†

By Mr. ANDREW JAMIESON, A.M. Inst. C.E., F.R.S.E., &c., Principal, College of Science and Arts, Glasgow.

The subject of electric lighting has lately received a large amount of attention from many of our most scientific and practical men, public interest has been greatly awakened regarding it, and the Patent Office has been inundated with specifications and applications all more or less proposing to give us perfect electric lighting. Numerous companies have been formed, with large subscribed and still larger nominal capital, with a view in some instances only to sell patents and patent-rights; in others, with the more honourable and honest purpose of making and installing their appliances, each one claiming its speciality or system to be the best either as a whole or in some particular feature.

Our leading scientific and engineering journals have of late been full of descriptions of this or that dynamo and electric lamp, or of some special installation or electrical exhibition, using terms and electrical phraseology which to some must have appeared new and difficult to understand.

There is at the present moment scarcely a town in the kingdom which has not had a trial of the electric light, and whose authorities are not worrying themselves as to whether they shall or shall not seek for a "provisional order," and thus have the right, under the Board of Trade, of supplying their inhabitants with "the light of the future."

In this paper I do not propose to describe anything very new or startling; neither do I wish to advocate one particular system in preference to another (for I have no pecuniary interest in any of them), but rather to lay before you a short description of how the various and necessary appliances are constructed and applied in order to produce electric lighting suitable for workshops and large spaces, and to make clear a few of the most common of the electrical terms, as well as to compare the efficiency and cost of electric lighting with that of gas lighting.

Practical Electrical Units of Measurement.

In the first place I shall define the several units of measurement required in measuring electrical currents in connection with electric lighting. The practical electrical units of measurement, now universally adopted by all electricians, were finally determined upon at the International Congress of Electricians, Paris, 1881, and British Association, 1882.

Since electricity, by whatever means generated, is the result of the expenditure of energy (mechanical energy, as a rule, in the case of electric lighting), and as the measurement of energy involves *space*, *matter*, and *time*, the three fundamental units adopted were the centimetre for length, gramme for mass, and second for time, which is termed the centimetre, gramme, second system, or, shortly, the C.-G.-S. system; and upon these fundamental units all the practical electrical units of measurement are based.

Analogy Between Water and Electricity.

An electric current may, for all practical purposes, be considered analogous to a fluid, under conditions somewhat similar to those by which water flows along a pipe.

1.—*Electromotive Force Compared to Head or Pressure.*—The difference of level or pressure, due to gravity, between the top and bottom of the water pipe (Fig. 1)*; in other words, the "*head*" causes the flow of water

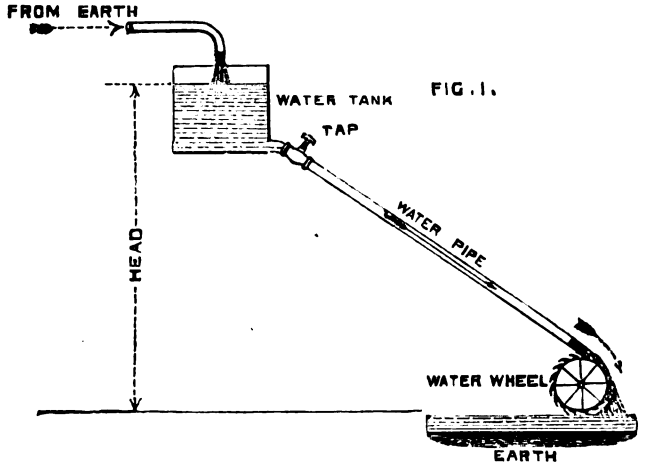

FIG. 1.

along the pipe, while the difference of potential or electrical pressure between the ends of copper wire (Fig. 2),* in other words, the *electromotive force*, as it is termed, causes the flow of electricity along the wire. The potential or pressure, in both cases, determines the power of doing work, as illustrated by the water now flowing from the elevated tank along the pipe and driving the small water-wheel on the table, and by the voltaic

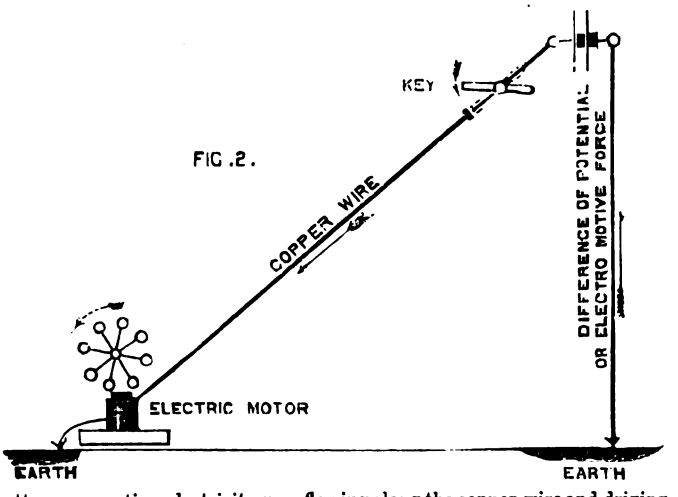

FIG. 2.

battery generating electricity now flowing along the copper wire and driving the small dynamo-electric engine, also on the table, and usefully employed pumping water.

2.—*Electric Resistance Compared to Friction.*—The *friction* generated between the running water and the inside of the pipe offers a certain amount of resistance to the flow of the water, and may be considered so far analogous to the *resistance* offered by the metallic conductor to the flow of the electricity along it.

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exist, and would be used literally by millions, if the source of electricity were but at hand, in the form of a friendly wire always ready to bring the needed power. . . . . Again, the establishment of a town supply of electricity will tend unquestionably to develop the industries of small workshops and home workshops, where a little power is required. I have already explained how, with steam power, small engines of one horse-power or less are uneconomical. But with electricity it is not so. The smallest electro-motors may be made just as economical as are the largest There is, moreover, another point in their favour. They may be made far smaller, lighter, more compact, and far cheaper than steam-engines of corresponding power. . . . . It is certainly possible to construct an electric-motor of two horse-power for ten pounds, and such a motor would be ample for the purposes of many small workshops. Why do we not, it may be asked, hear and see more of these little machines, if they are so excellent? Why do not people adopt them? The answer is simply they cannot be used until we have a central supply of electricity. I do not hesitate to affirm that such motors will be found to present an enormous economy in comparison with steam-engines of equal power. Take the case of a small workshop, which wants just two horse-power to turn a few lathes or drilling machines. A small steam-engine and boiler will, together, cost about £70, and the consumption of coal will be about 13lb. weight per hour. Instead of this, put in a motor costing, let us say, £20, which allows for handsome profits on manufacture. Here is a saving in capital outlay at once. Moreover, the motor may be put right into the workshop, for it is small—perhaps, 2ft. long, 18in. broad, and 1ft. high—and is not liable to leak or explode. The next point to consider is the cost of running it. Let us suppose that it has only an efficiency of 70 per cent., or that it only turns 7-10ths of the energy of the current into useful mechanical work. (Many motors will do far more than this.) Let us also suppose that the currents are furnished by a dynamo, whose efficiency is 90 per cent. (which figure is also capable of being attained in practice), worked by a large central steam-engine, consuming only 1½lb. of coal per horse-power. Allow 4 per cent. for loss, by resistence, in the conducting cables; this reduces the total efficiency of the generator to 86 per cent., and of that 86 per cent. only 7-10ths—*i.e*, 60·2 per cent.—is generally converted back into useful work by the motor. We have, then, 40 per cent. wanted in order to get 60 per cent. of useful work. How does this affect the coal consumption for two horse-power? At the central station 3lb. of coal per hour would suffice were there no loss in conversion into electric energy, and back again into mechanical power. As it is, 5lb. of coal per horse-power will be needed, 3lb. of which represent the 60 per cent. of useful power transmitted, and 2lb. to represent the 40 per cent. wasted. In practice, I believe, a far less margin of waste might be looked for. Yet even with this large waste there is still an immense economy effected, for we get our two horse-power by an expenditure of 5lb. of coal at the central station, instead of 13lb. of coal in the furnace of a small steam-engine. It is clear, then, that electricity offers an enormous future to small motor machinery."

* What is the proportion of coal used for the manufacture of gas in Great Britain, compared with the amount consumed in procuring motive power. The answer to this query amply justifies my view.

† A Paper read before the Institution of Engineers and Shipbuilders in Scotland.

* These models were kindly lent to the lecturer by Mr. White, Optician, and Messrs. Baird and Tatlock.

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3.—*Strength of Electric Current Compared to Flow of Water.*—The flow of the water along the water pipe, and the strength of the electric current along the conducting wire, are in each case determined by the pressure overcoming the resistance.

4.—*The Quantity of Electricity Compared to the Volume of Discharge or Volume of Flow of the Water* is in each case determined by the current passed in a second.

5.—*Power.*—In order to estimate the power of the current developed in each case, we have simply to multiply the total pressure by the current passed per second.

Exact Definitions of Practical Electrical Units.

1.—*Electromotive Force* = (E).—*The Volt* is equal to 10^8 C.-G.-S.* units of electromotive force, or about 8 per cent. less than the E.M.F. of a standard Daniell cell. Electromotive force is equivalent to the difference of potential between two points.

2.—*Resistance* = (R).—*The Ohm* is equal to 10^9 C.-G.-S.* units of resistance. It is equal to the resistance of a column of pure mercury 1·0624 metres long, of a square millimetre section, at the temperature of zero centigrade; or roughly, the resistance offered by 240ft. of pure copper wire, No. 18, B.W.G. (1-20th inch, or 1·274 millimetres in diameter), at 60° Fahr., is equal to one ohm. Resistance of copper increases with the temperature by about 0·21 per cent. per degree Fahr. Resistance varies directly as the length, and inversely as the sectional area of the conductor.

3.—*Current* = (C).—*The Ampere* is equal to 10^{-1} C.-G.-S.* units of current. It is the current produced by a volt through an ohm.

$$\text{Ohm's law...current} = \frac{\text{electromotive force}}{\text{resistance}}, \text{ or } C = \frac{E}{R}.$$

4.—*Quantity* = (Q).—*The Coulomb* is equal to 10^{-1} C.-G.-S.* units of quantity. It is the quantity of electricity given by an ampere in a second.

5.—*Power* = (P).—*The Watt* is equal to 10^7 C.-G.-S.* units of power. It is the power conveyed by a current of an ampere through a conductor whose ends differ in potential by a volt; or, in other words, the rate of doing work when an ampere passes through an ohm, and it is equal to 10^7 ergs (1·746th of a horse-power).

$$\therefore E \times C = \text{Watts, and } \frac{E \times C}{746} = \text{horse-power} = 33{,}000\text{lbs. per min.}$$

Motive Power for Driving Dynamos.

Before describing the dynamo, or generator of electricity, I shall just say a word or two about the most suitable machines for producing the mechanical power which has to be converted into electrical energy by the former.

First, we have the steam engine; second, the gas engine; third, the water-wheel or turbine; fourth, the wind mill; and a fifth has been proposed, but not yet put into practice, viz., a machine for utilising the rise and fall of the tides.

Of all these, the most suitable and, at the present time, the most popular, is the steam engine. Whatever kind of machine is adopted, it is absolutely necessary that so long as the power developed by it is applied to driving a dynamo, in direct circuit with the electric lamps, the motion should be as uniform as possible, in order to insure a steady current or electromotive force. For this purpose, in the case of the steam engine, it should be fitted with a sensitive and efficient governor, and it should be capable of easily furnishing the necessary power without in any way overstraining any of its parts, and be constructed of the very best materials and in the best possible manner, so as to minimise the chance of a breakdown. In the case of workshops, where there is an ample reserve of power developed by the shop engine, and the demand upon its energy does not alter very rapidly, it has been found suitable, in many instances, to drive the dynamo by means of the same; but this should not be attempted before carefully testing and considering well the capabilities of the engine.

The demand for electric lighting has necessitated a special class of engines for this work, and several well-known makers, notably Messrs. Marshall and Sons and Messrs. Tangye Brothers, have devoted much attention to this subject. The driving connection between the engine and the dynamo is usually carried out by means of belting either direct from the fly-wheel to the dynamo pulley, or by the intervention of a counter shaft.

It is only in the case of steamships, or where the space is limited, that the motion is communicated direct from the engine shaft to the dynamo, without the intervention of belting or gearing, and in such cases the engine must be run at a very high speed, or the dynamo so arranged as to work at an abnormally slow rate.†

Gas engines are becoming more popular, and, by using a fly wheel on the dynamo shaft, with long slack belting to counteract the effect of their somewhat irregular motion, they are, in many instances, found very serviceable. Sir William Thomson has adopted a six horse-power Clerk's gas engine at his laboratory, and Professor Blyth, at Anderson's College, an eight horse-power one, apparently with good effect.

Water power has, as yet, been but sparingly employed, either through the intervention of water-wheels or turbines, probably from the fact that where the electric light is in greatest demand, water is not available; but there cannot be much doubt that, as the mill-owners whose works are supplied with plenty of water power begin to realise the advantages of this form of artificial light, water power will be greatly taken advantage of; and, from the ease with which it can be manipulated, it will be found quite as efficient as the best steam engine, and certainly prove less costly.

Windmills and tidal machines are out of the question until that much-required desideratum, viz., the storage of electricity, can be economically effected.

* Electro-magnetic system. For the other units see Rankine's "Rules and Tables," sixth edition.

† As examples, we have the electric lighting on board the ss. "Servia" by means of Swan's lamps, where a Brotherhood's three-cylinder engine, running at about 600 revolutions per minute, drives direct Siemens's exciter and alternate current dynamos; and the ss. "Waihora," just completed this week by Messrs. Denny, of Dumbarton, and fitted throughout upon Edison's system with 150 incandescent lamps, the dynamo being driven direct by a three-cylinder Brotherhood's engine running at 500 revolutions per minute.

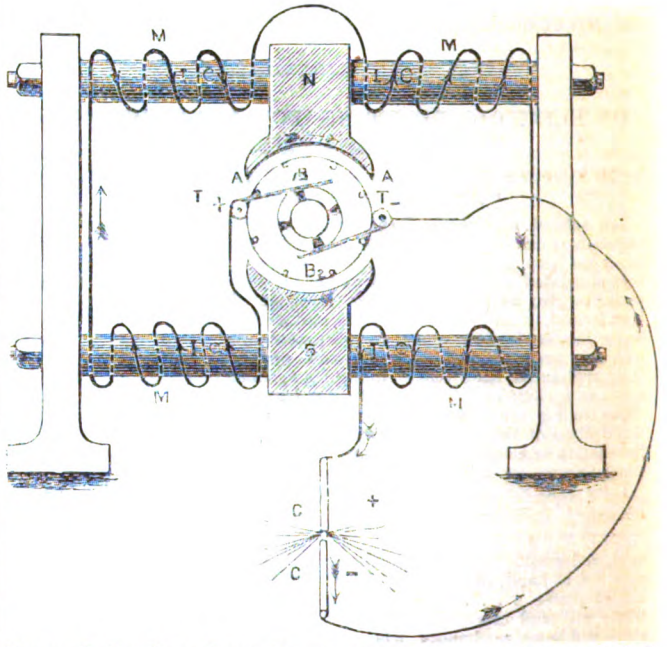
Dynamos.

We now come to the dynamo, or producer of electricity, for feeding electric lamps.

Gramme Dynamo.—To illustrate the general principle upon which this machine depends, your attention is called to Fig. 3, where

S represents	Shaft
A, A,	armature revolving between
N, S,	the north and south seeking poles of
M, M, M, M,	the electro-magnets, around the
I, C, I, C,	iron cores of which the wire from
T +	the + terminal of armature is wound as shown until it joins the
C +	carbon (+) or upper carbon of the arc lamp,
T −	the (−) terminal of armature being joined to
C −	the carbon (−), or lower carbon, of the arc lamp;
B_1, B_2	the brushes which collect the current from
C	the commutator, whose metallic parts are soldered to the nearest points of the coil of wire which forms the armature.

FIG. 3



Note.—In the above figure the armature is shown at right angles to its true position for clearness.

There being always some residual magnetism in the pole pieces N S and iron cores I C (after having once been magnetised), there exists a weak magnetic field between N and S, and the lines of force pass through the armature A A and its iron core, at right angles to the copper wire coiled round the same. Consequently, upon revolving the armature A A, its copper wire coil cuts these lines of force at right angles; a current is thus generated which is led off by the brushes in the direction shown by the arrows, still further increasing the magnetism of N and S, which, in turn, reacts on the armature core and coil until such a speed is attained that the electricity generated and flowing round M M M M completely saturates its iron cores and pole pieces with magnetism. Any further increase in speed will cause unnecessary heating of the electro-magnet coils, owing to the current passing through them being in excess of that required to saturate the cores and poles with magnetism.

Brush Dynamo.—In the Brush machine the armature coils are caused to revolve in a most advantageous manner, and as close as practicable to the poles of the electro-magnet, thus inducing great electrical energy (E × C) for a given speed. A reduction of the total resistance of the armature coils is made by cutting out of circuit two of them when in the least effective position. The commutator and its brushes are so placed upon the shaft, outside of the main bearings, that they can be easily got at for cleaning and repair, and are, therefore, more easily kept in good working order. The capability of generating currents of high electromotive force, with a mean current strength of 10 amperes, so that any number of lamps, from 1 to 40, may be worked in one circuit, in series, and the comparatively low speed at which the larger machines are to be driven, viz., 750 revolutions per minute for a 16-light machine are advantages.

The Brush system has been constantly at work at the well-known engineering works of Messrs. Mirrlees and Watson, and Messrs. Robert Napier and Sons for two years, where I find it has given great satisfaction, and it has lately been installed in Aberdeen and Dundee for their street lighting.

(TO BE CONTINUED.)

Underground Wires in New York.—A New York contemporary says:—"The Committee on Ferries and Franchises of the Aldermen of this city have presented to the Board a report on the petition of the New York Electric Lines Company for permission to lay electric wires under the streets. They recommend that the petition of the company should be granted, its operations, however, to be subject to the provisions of the ordinance regulating the laying of underground wires."

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ELECTRIC LIGHTING AND LOCOMOTION.*

Forty-three years ago it was practically shown by Jacobi, on the River Neva, that locomotion by the aid of electricity was possible. No experiment, then, merely to prove this fact is needed at the present day. Nevertheless, both experiments and calculations are still necessary to convince the world that electric locomotion is not only possible but also commercially practicable. That electric transmission of power possesses great advantages—arising, first, from the small weight of the electromotor per horse-power developed by it; secondly, from the fact that large amounts of power can be transmitted through quite thin flexible wires—must also have struck any one who has ever seen a powerful machine driven by electricity. Its disadvantages are generally summed up in the single sentence that it is too expensive. But people, as a rule, do not trouble themselves to inquire whether it is really more expensive than other modes of transmitting power, and whether, if this be the case, it arises from some inherent defect in the principle itself, or merely from some removable imperfection in the machinery hitherto employed for the purpose.

At the present day the public may be divided into two classes—the one who thinks that electric locomotion and transmission of power will act as a sort of philosopher's stone, and solve all difficulties: the other, that it is a new fangled notion, and carefully to be shunned. The first class implores to be allowed to buy shares in any company that can in any sort of way have the word "electric" tacked on to its title, while the other buttons up its pockets at the mention of the word electricity, and busies itself with what it terms "something useful and practical." And, unfortunately, the repeated failures of the sanguine members of the first class to reach the El Dorado they have imagined to themselves only strengthens the belief of the more cautious members of the second class in their shrewdness and in the wise decision they fancy they have arrived at, that electricity is a mere will-o'-the-wisp.

But you, I am sure, will not have that opinion when you have seen to-night what can be done by electricity. I turn on this electric tap, and at once this fan commences to revolve rapidly, and sends forth a rush of wind. That, perhaps you will say, could as well be done by a belt driven by a steam engine: but I turn on another tap in the same supply wire, and at once the fan is lighted up by this electric lamp. That could not have been done merely by a steam engine. Again, a third tap; this electric fire burns, and the water starts boiling in this glue pot. [Experiment shown.] This thin flexible wire then furnishes a supply of electric power which can at will be used for producing motive power, light, or heat.

Now, to produce this supply of electric power, we must first have a steam engine, a gas engine, a water-wheel, or windmill to produce motion, and a dynamo machine to convert the mechanical energy into electric energy. These may be in the same room, or in another part of the building, or in another street, or away in the country; the electric power may be brought by a wire and used directly, or it may be stored in Faure-Sellon-Volckmar accumulators and used at some subsequent time, as I am doing now, thanks to the courtesy of the Electric Power Storage Company. Indeed, I may mention that in all my experiments I am using only stored electricity; and in this room, where we are utilising this supply of electric power, we must have an electro-motor if we want motion, an electric lamp if we want light, and an electric fire if we want heat. The transmission of power by electricity seems, then, very useful. Can it be made commercially remunerative?

As there are, doubtless, many in this hall who are deeply interested, either from scientific or from commercial reasons, in the answer to this question, and generally in the practical applications of electricity, it will be well to commence this lecture by considering, as shortly and as popularly as possible, what are the real difficulties besetting electric transmission of power, and what are the means electric engineers are proposing for surmounting them. Let us then attack the question together, not in the rosy, sanguine humour of the promoters of electric bubble companies, nor with the cold, hard scepticism of those who forget that with the early locomotive engines the fireman had to run along the road by the side and stoke, but as common-sense Englishmen who are anxious to know whether at the present moment the pros or the cons are in the majority.

An electric current, as you have seen, can produce heat; but, unfortunately, not only can an electric current produce heat, but an electric current always is producing heat. Now, while it is very proper that heat should be produced in an electric lamp or furnace, it is quite out of place in the dynamo machine or generator of electricity, or in the leading wires, or in the electro-motor, which converts the electric energy into mechanical energy. In all such cases the heat produced by the electric current corresponds with the heat produced by friction in machinery, and causes the same sort of waste of power.

But this loss of power, we shall see, is not necessarily so very great even when the power has to be transmitted a considerable distance, for when there are a number of machines, lamps, or motors that have to be worked by electricity there are two ways in which they may be connected together. They may all be joined in what is technically called "parallel," or they may be connected in "series." In the first case the current (as was illustrated by diagrams) that passes through any one of these machines does not pass through any other, and the generator must produce a large current—as large, in fact, as the sum of all the currents passing through all the machines. In the second case, the "series" arrangement, the same current of electricity passes through all the instruments one after the other in succession, and the generator only produces a current equal to that passing through any one of them. The ordinary methods of supplying houses with water or with gas are examples of the parallel system, because the water or gas that is supplied to any one house does not go to any other. The postman brings the letters and the boy leaves penny papers at a number of houses in parallel, while a copy of *The Times*, lent out at a penny an hour, is furnished to a neighbourhood in series.

And just as a newspaper or a book from a circulating library loses in freshness, although gaining in thumb-marks and dog-ears, when supplied to its readers in series, and as water loses head or pressure as it flows down a stream, so electricity loses its potential or power to work in passing through a number of machines worked by it in series.

To work, then, a number of electric motors or lamps in the multiple arc system we must at starting supply a large quantity of electricity at, it may be, only a low potential or pressure; whereas, if they are joined in series, the current may be small, but the initial pressure must be great.

In all electric railways and tramways constructed up to the present time the multiple arc system has alone been adopted. This you will see from the photographs that I will now project on the screen of all the most important electric railways yet constructed. First comes three photographs [Photos. on screen] of the small circular railway, 900 yards long, of 3ft. 3in. gauge, laid in the grounds of the Berlin Exhibition in 1879, and exhibited in 1881 at the Crystal Palace, Sydenham; next, a photograph of the Lichterfelde Railway, near Berlin; then the electric tramway in the Champs Elysée, Paris; and that of Charlottenburg, near Spandau. The latest electric railway, the one six miles long, now in course of construction at Portrush, near the Giant's Causeway, in Ireland, I shall reserve, as I shall have much to say about it later on in these lectures.

[Photographs were then exhibited of the various electric railways, which were described in detail.]

But the amount of power lost in heat when a certain definite amount of power is being transmitted through a given wire is very different, whether the multiple arc or the series system be adopted, because the heat produced per minute depends on the strength of the current used in the transmission and not in the amount of power transmitted. Indeed, it depends not merely on the current, but on the square of the current, so that if the current be doubled the waste of power becomes four times as great as before. Economy in electric transmission, therefore, requires small current, and, if much power is to be transmitted, small current necessitates high potential and the motors or lamps working in series. Similar considerations apply to the transmission of power by water; to obtain great economy high pressure is absolutely necessary. The accompanying tables, taken from Professor Perry's Cantor Lectures, show the amount of loss of power when different amounts are transmitted different distances by water at an united pressure of 700lb., and at 1,400lb. per square inch, as well as the amount lost when electricity is employed with a difference of potential between the terminals of the dynamo, first of 8,000 volts, secondly of 80,000 volts.

TRANSMISSION BY WATER.

PRESSURE 700LB. PER SQUARE INCH AT ENTRANCE.

Horse-power given in.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		H.-p. lost in 1,000 miles.
	6in. pipe.	3in. pipe.	6in. pipe.	3in. pipe.	6in. pipe.	3in. pipe.	6in. pipe.
500.....	·125	4	1·23	40	12·5	400	125
1,000.....	1·0	32	10	320	100	—	—
2,000.....	8	256	80	—	8 0	—	—
4,000.....	64	2048	640	—	—	—	—
8,000.....	512	—	5120	—	—	—	—
16,000.....	4096	—	—	—	—	—	—
32,000.....	—	—	—	—	—	—	—

PRESSURE 1,400LBS. PER SQUARE INCH AT ENTRANCE.

Horse-power given in.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		H.-P. lost in 1,000 miles.
	6in. pipe.	3in. pipe.	6in. pipe.	3in. pipe.	6in. pipe.	3in. pipe.	6in. pipe.
500.....	·015	·5	·15	5	1·5	50	15
1,000.....	·125	4	1·25	40	12·5	400	125
2,000.....	1	32	10	320	100	—	1000
4,000.....	8	256	80	2560	800	—	—
8,000.....	64	2048	640	—	6400	—	—
16,000.....	512	—	5120	—	—	—	—
32,000.....	4096	—	—	—	—	—	—

TRANSMISSION BY ELECTRICITY.

POTENTIAL 8,000 VOLTS.

Horse-power given to wire.	Horse-Power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		Horse-power lost in 1,000 miles.	
	½in. wire.	¼in. wire.	½in. wire.	¼in. wire.	½in. wire.	¼in. wire.	½in. wire.	¼in. wire.
500 ...	0·7	2·7	7	27	70	270	—	—
1,000 ...	2·7	10·8	27	108	270	—	—	—
2,000 ...	10·8	43·2	108	432	1080	—	—	—
4,000 ...	43·2	172·8	432	1728	—	—	—	—
8,000 ...	172·8	691·2	1728	6912	—	—	—	—
16,000 ...	691·2	2764·8	6912	—	—	—	—	—
32,000 ...	2764·8	11059·2	27648	—	—	—	—	—

* Lecture I., delivered by Professor Ayrton, F.R.S., at the London Institution, February 22, 1883.

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POTENTIAL 80,000 VOLTS.

Horse-power given to wire.	Horse-power lost in one mile.		Horse-power lost in ten miles.		Horse-power lost in 100 miles.		Horse-power lost in 1,000 miles.	
	¼in. wire.	¼in. wire.	¼in. wire.	¼in. wire.	¼in. wire.	¼in. wire.	¼in. wire.	¼in. wire.
500 ..	·007	·027	·07	·27	·7	2·7	7·0	27
1,000 ..	·027	·108	·27	1·08	2·7	10·8	27·0	108
2,000 ..	·108	·432	1·03	4·32	10·8	43·2	108·0	432
4,000 ..	·432	1·728	4·32	17·28	43·2	172·8	432·0	1728
8,000 ..	1·728	6·912	17·28	69·12	172·8	691·2	1728·0	6912
16,000 ..	6·912	27·648	69·12	276·48	691·2	2764·8	6912·0	—
32,000 ..	27·648	110·592	276·48	1105·59	2764·8	11055·9	—	—

But high electric potential or pressure is generally considered to mean danger to life, and series working of machines or lamps has this disadvantage, that if from any accident the current is stopped passing through one it is stopped passing through all.

The danger arising from the use of high potential can be very much diminished if, instead of using the earth as part of our return circuit, we employ not only an insulated wire to convey the current, but also another insulated wire to bring it back again, and if in addition the current flowing through the whole circuit is not intermittent. This may be shown by the following experiment:—Attached to these wires, well insulated from the ground, are the insulated coatings of this battery of charged Leyden jars. Now, although the difference of potentials between the wires is some thousands of volts, far, far greater than is at present used, or proposed to be used, in any system of electric transmission of power, I can, as you see, touch either wire with perfect impunity. But if either of these wires be replaced by a wire in contact with the earth, say replaced by one of the gas pipes, and I were now to touch the other, I should receive a violent shock.

As, however, my love of electric experiments does not extend to shocks, I will touch the insulated wire by deputy, using this metallic rod, and the result is, you see, a bright spark. [Experiment shown.] Both the going and return wires, therefore, should be insulated.

But, next, the current flowing in them must not be discontinuous if danger is to be avoided. For if, instead of keeping the difference of potentials between any two points in the two insulated wires constant, I allow rapid fluctuations in this difference to take place, then, no matter how well the wires be insulated, a violent succession of shocks will be received on touching either of the wires, even although the other be not touched, so that no circuit in the ordinary sense is completed through the body. To show this experimentally I shall replace this insulated battery of Leyden jars with an induction coil, which, as well as the voltaic cells used in charging it, are thoroughly well insulated from the earth in every part. Let me, however, touch either of these wires—again by deputy—and you see bright sparks passing to the earth. [Experiment shown.] Bear in mind that I am touching one wire only, not both, so that, although the Ruhmkoff coil is doubtless an old friend to you, I am using it to-night in a new way to illustrate my point.

Now let us consider why it is that when a current goes and returns by a wire completely insulated from the ground no shock is experienced when the current is perfectly steady, even if a bare part of the wire be touched; but if there are rapid variations in the current strength severe shocks are felt even if only one part of the wire be touched.

In each case the effect of touching the wire is to reduce the potential of the point touched to that of the earth, and to effect a corresponding alteration of the potential along the whole line. This means the addition to a subtraction of a certain quantity of electricity from the wire. In the case of a perfectly steady current this operation only occurs *once* for once touching the bare wire, and unless the electrostatic capacity of the wire be very great, or the potential of the point touched immensely different from that of the earth, this *single* addition or substraction of electricity produces hardly any perceptible feeling. But in the case of a varying current the potential of the point would naturally be undergoing constant variations of potential, so that in order to keep the point touched at the same potential as that of the earth, constant additions and subtractions of electricity are necessary, and if these occur with sufficient rapidity a severe shock is produced, even although the body forms no part of the main circuit.

A single puff of air through this syren produces no audible sound, a rapid succession of even minute puffs a loud roar; so the single small electric discharge is not perceptible, but the rapid shower of Lilliputian arrows is terribly painful. This, indeed, is the same analogy Professor Perry employed in his lecture at the Society of Arts to prove the powerful action of rapidly recurrent effects in connection with our method of signalling to ships by means of sound waves sent through the water.

High potential, I have explained, is absolutely necessary for economy in electric transmission of power, and I hope I have also made it clear to you that, contrary to the received opinion, this high potential is not necessarily at all dangerous to life if the currents employed are not at all discontinuous. But the discontinuity of current we have to deal with is not merely the discontinuity that exists in the so-called reverse current machines. Even many dynamos, like the Brush, do not produce a really constant current, although generating a current of sufficient mean constancy to cause a perfectly steady deflection on one of the ordinary ammeters of Prof. Perry and myself, an instrument, be it remembered, so dead-beat that it records with perfect accuracy the change of current produced every time the joint in the driving-belt passes round the pulley of the dynamo, as well as the regular increase of current at each of the explosions of the gas in the cylinder of a gas engine.

The variations of current I am now referring to occur many hundreds of times a minutes, and although they cannot be detected by ordinary current meters, and although but little attention has been given to them, they are, in my opinion, a source of great danger when the dynamo produces a high electromotive force.

In any machine for the mechanical production of electricity a coil must, as you no doubt all know, be alternately rapidly brought up to a magnet and then withdrawn. Bringing up the coil produces a current in one direction in the coil, and withdrawing it a current in the opposite; and although by a simple piece of mechanism, called a commutator, the direction of the current in the external, or useful, portion of the circuit may be always kept the same, even although the direction of the current is alternately reversed in the coil no mechanism can make the coil produce a current at the moments of rest, when it changes its direction of motion. Wheatstone, in 1841, proposed to overcome this difficulty by combining two or more dynamos in series, like the two cylinders of a steam engine, in such a way that the current produced by the one was strongest when the current produced by the other was weakest; but Pacinotti, in 1860, showed us scientifically, and Gramme, in 1870, practically, how to combine a number of moving coils in one machine so as to give a current comparable in steadiness with that produced by a voltaic battery. The power of any dynamo depends roughly on the speed at which the coils move and on the strength of the magnetic field in which they move. Now, from the construction of the well-known Gramme machine, the strength of this magnetic field is necessarily weak when the machine is made of large size so that the greater power and efficiency which ought to come from enlarging the machine is partially compensated for by the relatively weaker magnetic field; indeed, even in a small Gramme machine the magnetic field is probably weaker than the magnetic field produced long ago in the old reverse-current machines of Holmes and Wilde. Hence more recent inventors, like Brush, have adopted a compromise between the perfect uniformity of strength of current obtained with the Gramme dynamo and the strong magnetic field in the old reverse-current machines. But in almost all the high electromotive force dynamos continuity of current has been somewhat sacrificed to strength of magnetic field. The plan, however, described in 1879 by Professor Perry and myself of oblique coiling of the armature, has enabled us, especially in our recently-constructed machines, to combine the continuity of current produced by a Gramme with the powerful magnetic field necessary for obtaining high electromotive force, and these results are in no way diminished when the machine is increased to the size necessary for utilising hundreds or thousands of horse-power and for obtaining that high efficiency which both theory and practice show is obtainable with the use of very large dynamos.

The next point to consider is how can we measure the amount of this dangerous discontinuity in the current produced by a dynamo without having to resort to the inconvenient process of killing off a certain number of people. We want a "discontinuity meter," and such an instrument I have here, employed by Professor Perry and myself for this purpose. It consists simply of an induction coil in which both the primary and secondary circuits are of thick wire. The one is put in the main path of the current, the other is attached to one of our "Spring Ammeters," which measures the mean square of the strength of the reverse currents produced in the outer secondary coil by the intermittencies of the main current.

Now, what are the results obtained when such an instrument is practically employed? Why, we find that when a current of ten amperes, produced by a three-light Brush dynamo, is flowing through the primary, there is a reverse current through the secondary which increases to about five amperes, when the secondary is nearly short-circuited, and which, be it remembered, is produced merely by the commonly ignored discontinuities in the current in the main current produced by the Brush machine. On the other hand, when the same current, ten amperes, is sent through the primary by a Gramme machine running at about the same speed, no visible current, certainly not a quarter of an ampere, is produced in the secondary. Hence it is clear that the continuity of the Gramme current is immensely greater than the continuity of the Brush current.

A telephone may also be used as a discontinuity meter, the two terminals of which are in different experiments attached to two points close together in the main circuit of the dynamo. For quantitative experiments these two adjacent points in the main circuit should be selected, so that in all cases there is the same difference of potentials between them, and then the pitch of the note heard in the telephone will tell the number of variations per minute in the main current, and the loudness of the note the magnitude of such variation.

And I strongly advise any one who is procuring a high electromotive force dynamo to ascertain for himself, before purchasing, the magnitude of the discontinuity factor of the machine, and about which he will find no information, as a rule, given in any description of the machine.

The other inconvenience arising from the use of high potential and small current, viz., that as the motors and lamps must be put in series the accidental stoppage of the current passing through one stops the current passing through all, is easily remedied by the use of what are technically called "cut outs." A cut out, as you see, consists of an electro-magnet wound with comparatively fine wire, and which allows a small part of the total current to pass through it instead of through a particular motor or lamp. If, however, from no failure in the generator, no current can pass through the motor or lamp, then more passes through the cut out, the electro-magnet of which becomes stronger than before, attracts the armature which closes this side circuit, and so allows all the current to flow by the bye-pass thus formed.

We have seen, then, that for economic electric transmission of power high potential must be used; secondly, to avoid danger to workmen and others likely to touch the wires, both the going and return wires must be insulated, and also the current must not only be what is practically called a constant current, but must not be subject to the rapid variations in intensity such as are produced by many existing dynamos.

Next, in a satisfactory system of distribution of power, be it electric or otherwise, the supply should be exactly equal to the demand: a greater or less demand for power on the part of any consumer should not be accompanied by a less or greater supply to any other consumer of power. In the distribution of gas to a town this problem has never been completely solved. Owing partly to the mass possessed by the gas in the mains no automatic regulator has ever yet been devised to use at the gas works so perfect that our burners do not flare at about nine o'clock in the evening, when the consumption of gas in the town is being rapidly diminished; and, indeed, at the present day a gas engine in a building even fed direct from the main will cause unpleasant pulsations in all the lights in the same building, also

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fed directly and separately from the main, so that the number of explosions in the gas engine can be counted all over the building. The pressure regulator at the gasworks cannot act quickly enough, so that Sugg and others have devised automatic regulators to attach to the burners themselves in the houses.

Constant pressure in the case of gas corresponds for electric lamps or motors in parallel, with constant difference of potentials between the leads and with constant current for lamps or motors in series.

As an illustration of the importance of these considerations you see this battery of three Grove's cells will light this incandescent lamp, or, it will drive this electro-motor, but when I attempt to unite them in multiple arc together, the light of the lamp is, you observe, much diminished in intensity, due to the fact that the difference of potentials at the ends of the carbon filament is diminished when the motor is started. Again, I have these two lamps in series; I now allow the current to pass through a third lamp in the same series, and you observe that all the three are duller than either of the two were before, due to the current being diminished. [Exp. shown.]

And, conversely, if from a sudden diminution in the consumption, arising from many of the lamps being suddenly turned off, the difference of potentials between the main wires is much increased, all the remaining incandescent lamps are suddenly broken. Indeed, when the governing of the difference of potentials or of the currents was much less perfect than at present, it was no uncommon thing for hundreds of incandescent lamps, costing many pounds, to be suddenly broken.

Consequently, the problem of supplying either constant difference of potentials in the parallel system, or constant current in the series system, independently of the consumption of electric energy, and which might at first sight appear rather a dry and uninteresting problem, is in reality of great practical importance, since it must be solved before one train on an electric railway shall not suddenly start going faster because another has stopped, or before the electric lights in one train shall not become dim or break because the passengers in another train have turned theirs on or off. It is a problem, therefore, to which electrical engineers have devoted much attention during the past few years.

(TO BE CONTINUED.)

THE TELEPHONE CASE.

JUDGMENT.

We have already given the judgments of the Master of the Rolls and Lord Justice Lindley in this case. We now give that of Lord Justice Bowen, which ends our report so far as the details of the case are concerned:—

Lord Justice Bowen: I am of the same opinion. With regard to the questions which arise on the construction of the document, I confess that I think the case an extremely difficult one. I am not sure that there have not been times in the history of the Patent Law when documents worded not more obscurely than this have been upset; but I do think that applying the principles which have obtained in the construction of documents through, at all events, the greater portion of the history of the Patent Law, that one can see one's way clearly to disposing of this appeal in the way in which we have done. It would be wrong to disguise from ourselves or from those whose case we are deciding, that as regards the construction of the document we are deciding the case on what may be called the benevolent principle, the principle of which has been called in many cases the benevolent principle of construction, and that is the way Mr. Hunnings's powerful, and in some respects very difficult, argument is made out; and it is in order to answer him that I propose to say a few words on what I think, and I believe the rest of the Court think, about the benevolent principle of construction. It is for the last hundred years that that principle has been applied. It was applied as early, and for anything I know, applied before, but certainly as early as Windon's case in 1st "Turnbull;" and it has been applied as lately as Hinck's case, when the Master of the Rolls, in language which I read again because I think it will make clear the few words I am going to say about it, said. The Master of the Rolls in that case says:—"I am anxious, as I believe every judge is who knows anything about the Patent Law, to support *bonâ fide* inventors who have actually invented something novel and useful, and to prevent their patents being overturned upon mere technical objections or mere cavillings with the language of their specification so as to deprive the inventor of the benefit of his invention. This is sometimes called the benevolent mode of construction. Perhaps that is not the best term to use; but it may be described as construing a specification fairly with a judicial anxiety to support the invention, if it can be supported on a reasonable construction of the patent. Beyond that the benevolent mode of construction does not go." That seems to me exactly to define what the benevolent principle of construction is; and it is, in fact, no new principle. It is an old principle of the law applied to a very special subject matter. It is not the dispensing of charity to a patentee. It is not that the Court will, because they wish to favour him, make him a present of an impossible construction, giving to the words of the patent a construction which cannot be found there; but it is simply this—that if more than one construction is possible, they will, when the patent is a meritorious one—when an idea is a meritorious one, and when there has been complete discovery—because that must be remembered as an essential part of the condition upon which we act—when there has been a *bonâ fide* discovery by the patentee, they will put the more favourable of the two possible constructions upon the specification with the intention of making it good. That seems to be nothing more than the old principle of law that a benignant interpretation is to be put on the document in order to give it effect, if it is to be gathered from the surrounding circumstances that it was intended that the document should be effective. That sort of presumption in favour of the effective nature of the document meant to be effective has been drawn from both inside the document and outside the document. There are cases in which presumption is outside the document, and where it ought to be made in order to give it an effect which it was obviously intended to have. There are cases in which the presumption ought to have been made on the construction of the document itself. The benevolent principle applied to the Patent Law is really an application of the old doctrine of construction. It really only comes to this—that there has been a meritorious invention, that when the patentee has disclosed adequately to the public the nature of his invention, the Court will put themselves, for the purpose of construing the document, in this position—they will remember that the patentee is an honest man and a *bonâ fide* meritorious inventor; and in construing his patent we will assume that he was speaking as such to a public which was competent to understand what he said. So defined, it seems to me that there is nothing in the House of Lords' decision to which the Master of the Rolls has referred, and which extends that doctrine. It may be that in the House of Lords they had in that case put a somewhat unexpected reading on a particular document; but they did not or could not extend the principle which I have ventured, no doubt imperfectly, to express. And the reason of that is this—because the doctrine is a principle of construction, not of misconstruction. It is intended to guide to a reasonable interpretation, not to be an excuse for misconstruction. Therefore we begin by reading this specification in question by remembering that, if there are two reasonable possible constructions to be put upon the specification, the more favourable one is to be adopted, if we think that the invention is a meritorious one, and it has been a *bonâ fide* attempt to discover the exact nature of the thing. That being so, I confess that I feel no hesitation in applying it to the Bell receiver. I will not go through again the explanation of the construction which has been put upon the claim by the Master of the Rolls and by Lord Justice Lindley. Mr. Hunnings argued very powerfully that the claim was too large. In one reading -and, perhaps, in the main reading—his argument can hardly be honest, and I think on the most obvious reading it is too large. But that is not the question. The question is whether there is not a reasonable reading, although not so reasonable; and it seems to me that there is, and on that ground I think that the objection to this patent fails. But next we have to consider the question of infringement and the anticipation, and, in order to decide this properly, we have to make up one's mind what it is that Bell's specification claims as regards the receiver. I think that at all events these points are clear. In reading the description upon page 18, it says that, in the first place, the instrument offered to the public by Bell has got a receiver and transmitter; in the second place, the receiver is to be a plate, or may be a plate; in the third place, it is to be a plate at all events in front of the magnet, and attached in front and close to it, with a fixed circumference. The exact method of the fixture appears not to be material to discuss; and, lastly, the drawing is important because an instrument is shown in a way in which every workman can make it. You have, therefore, not only the luminous idea expounded, but the very instrument which enables it to be worked shown; and I do not hesitate to say that as far as I can judge a drawing in this kind of patent may be looked to just as much as anything else to see what is the instrument which the patentee has brought before the world. The explanation of the principle is not necessary. What he has to do is to show an instrument and show what is wanted. Applying that to Bell's receiver, it seems to me that there has been an infringement in both cases. In fact, Mr. Hunnings himself abandoned that part of it. But there remains the more serious part of the question, as to whether there has been an anticipation. As regards the Reis instrument, I think that one may pass over it lightly, for the reasons given by those who preceded me. But has there been an anticipation in what was done by Sir William Thomson at Glasgow? I am only going to say a few words about the legal test to be made here, just as I said a few words about the benevolent construction. There is no new law laid down in this case, nor can there be any new law. The law about anticipation is as plain as possible. I do not know a better *resumé* of it than that given in the Plympton case by the Master of the Rolls: "The inventor only escapes what constituted the monopolist construction if he is the first and true inventor, and if the manufacture which he puts forward is not in use at the time of the alleged invention." Now we have not got to consider the question of use. But we have to consider when Bell's patent was out, and the person who is clothed with his rights is entitled to say that an invention is mine. An invention is not made if all that is done is to put forward an idea which was not in the stock of public knowledge before, and where there was only a pretence to sell it to the public in return for the monopoly. That really renders the issue very simple. Has there been a previous publication of the same thing? In discussing that question, application really means exactly as much and no more than it does when we are dealing with the publication of the specification itself. Has there been a publication of the same thing at Glasgow, and has it taken an effectual and practical shape? Has the contribution to the world's knowledge been substantial? I take it what I consider to be good law (not perhaps as applying in every single word to this instrument, but as embodying the principle by which we test the cases of previous publication) as laid down by the Lord Chancellor when he used this language:—"On principle I conclude that a prior knowledge of the invention to veto a patent must be knowledge equal to that required to be given by a specification, or rather such knowledge as will enable us to conceive the very discovery, and to carry the invention into practical use." Now, what are the facts? Sir William Thomson came to the British Association. He came with an instrument, and he showed that instrument to the British Association, and he allowed the instrument to lie not only on the table, but in the laboratory of the Glasgow University for some time; and it is unquestionable that everybody who chose could see it, and there is evidence that many did see it, and that many did appreciate it, and attach as they could their own ideas to it, and perhaps rightly, and perhaps reasonably they appreciated what was shown to them, because we had not only accounts given in contemporary publications of the instruments as seen, but also we have drawings more or less imperfect, but still substantially representing what was visible. Now I think it would be almost childish in any one who sends an instrument to the British Association to say that he did not intend it to be a publication of some sort; and what is the publication that he intends? Why the instrument that he sends. A man does not send an instrument to the centre of the scientific world to be shown to the scientific men of this country without intending that they should see what they saw, and without intending to make a present to them of what he sends. I think there was a publication, and the question is of what? Was it a publication of the Bell instrument, or, rather, was it a publication of an instrument substantially the same as Bell's, or which by an ordinary

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workman could be turned into a Bell instrument? As shown to the world at Glasgow it had unquestionably a lid. I find that on the evidence there was an unmistakable crease. If I had to say as to its sound I should say it had some, not so much as at present. But still I will not decide this case on the assumption that there was a crease at Glasgow. What is said is that it had not got the adjustment which the Bell instrument has got. It was to be worked on the same electrical principle, no doubt. In the first place, it was not identical in appearance, and it was not the same to look at. It was argued in the court below, and was contended at one time before us, that the Glasgow instrument as shown at Glasgow was of no utility. I think that that was a false point if pressed to that length in the court below, because we have seen it work, and know that it works well under certain conditions. We know, now, that it is not true that the Glasgow instrument cannot be made to speak even in its present shape. I do not feel driven to an assertion one way or the other as to whether, in considering the question of utility of the Glasgow instrument, one must judge solely of what was known at the time or since. It seems to me that neither is exactly right, because I can conceive an instrument being useless at the time when its use was not known, but which afterwards became useful. The difficulty would be one for the tribunal to decide; but it would not be a difficulty of law. Again, I can conceive an instrument being useful at one time, and which ceased to be useful. That is not a difficulty in the law, but it may be difficult for the tribunal to decide. But I do think it is clear in judging of the two instruments, and making up one's mind whether the Bell is substantially the same as the Glasgow one we must take care that the conditions under which we judge one and the other are the same, because otherwise there is no such thing as comparison. You cannot compare two things except under fairly similar conditions. There is no doubt some complication introduced into the Patent Act, but down to the time of this trial in this court, and, as far as I know, up to the time of the trial in Mr. Justice Fry's court, the Glasgow instrument never was tried with any except the old transmitter at the time that Sir W. Thomson gave his evidence, and I believe the other witnesses, or some of them, had not seen the Glasgow transmitter under very favourable conditions. We have tried it under favourable conditions; and we know, under more favourable conditions, it works nearly as well as the Bell receiver. That does not seem to me to help the appellants. We come back to ask the question—Would the ordinary workman, when that Glasgow instrument was presented to him, have turned it into the Bell by the exercise of no more than ordinary and reasonable skill without the incitement of invention? because you have nothing to do with the invention of a workman, but must take his ordinary knowledge. It seems to me that the ordinary workman would not have turned it into the Bell, and for this very reason, that the Bell presents a complete adjustment, and the Glasgow instrument did not. Now, it is all very well to call a complete adjustment nothing. In many a patent case, no doubt, an adjustment is nothing more than that. But the fallacy seems to me to be that in a very obscure subject, at a moment of time when knowledge was limited, it was impossible that "mounting" could be disposed of by calling it simply "nothing." The condition in which the Glasgow instrument was presented at Glasgow was such as to give no indication at all to those who saw it as to what was the best adjustment or the best way to use it. In dealing with the subject of electricity, at the present moment it is so obscure that I am not sure that scientific men would say positively as to how the transmitter works; and, going back six years, into the very twilight of the discovery, no one would say that an instrument which presented no means as to what was the best adjustment is the same instrument which shows it. I agree, in considering this question, one must endeavour to see whether there was a crease at Glasgow, or to make the case clearer to show that there was a crease in the Glasgow instrument. If there was a crease, it seems to me that that was obviously misleading, because the "crease" would prevent the lid from being drawn in the ordinary way. "If there was no crease, well, then, at all events," say the appellants, "if proper strength was applied in the current the lid would fall." Aye, if proper strength was applied, and if people knew as much about it as they do now. But they knew nothing about it then, practically, except that it would work, and they knew not under what conditions, and still less by what conditions it worked best. And the best reason for thinking that the ordinary workmen would be put off the scent is this—that Sir Wm. Thomson, the first authority, was put off the scent himself. Let us go back one moment to consider what is material in the various points of adjustment indicated by the Bell patent. We are told there is a plate in front; and it is to be attached to something. We are told that it is close to the main: and we are told what the circumference is to be; and, lastly, there is a drawing. Can any reasonable man believe that if Sir Wm. Thomson had been told all these special particular facts at Glasgow, that in the attempts to make the instrument work feebly and badly, though it might work better, he would not have been assisted. I come to the conclusion that he would have been assisted; and that seems to me sufficient in this case, where the *onus* lies upon those who seek to upset a *bonâ fide* patent, that it establishes a proposition urged in reply that there has been no such complete anticipation at Glasgow of the same instrument in as practical a shape as is necessary to make out that the enrichment of the stock of knowledge of the world which the Bell instrument, upon the confession of the respondents, has made.

SUBMARINE TELEGRAPH COMPANY.

The half-yearly general meeting of the proprietors in this Company was held at the offices, Throgmorton-avenue, London-wall, on the 21st inst., under the presidency of Sir James Carmichael, Bart.

The SECRETARY (Mr. S. M. Clare) having read the notice convening the meeting, the seal was affixed to the register of shareholders, and the report of the directors was taken as read.

The CHAIRMAN said: I have much pleasure in moving the adoption of the report and accounts before you, which, I trust, you will find satisfactory, though we have not been able on this occasion to recommend quite so large a dividend as at the last half-yearly meeting. This is very easily accounted for: in fact, I think by looking at the report you will see that one of the principal items in the increase of our expenditure has arisen from the repair of cables. Those repairs last year have been rather onerous owing to the very exceptional state of the weather. We have had a series of storms and gales, which not only caused damage to our cables, but also very much delayed the operations of our engineer in carrying out the necessary repairs. In the North Sea for the last two or three months there has not been sufficient interval of calm weather to do any constant work. When the engineer has been on the ground after a few hours' work he has been compelled to seek shelter in Lowestoft or some neighbouring port. That fully accounts for the extra expense of the cables, but that is one of those circumstances which submarine telegraph companies must be subjected to, and over which directors can have no possible control. Notwithstanding these drawbacks, our traffic would have been considerably better than it is had it not been for the unsettled state of politics in France, which, no doubt, as you are all aware, has prevented to a large extent not only speculation on the Bourse, but to a certain extent has paralysed all commercial enterprise in the country; in fact, you saw that from the late deputation of merchants and others who waited on M. Grevy, with the view of improving matters. Everything that affects the French Bourse affects us, and diminishes our traffic, because they are our best customers. However, notwithstanding the difficulty that we have had to contend with, I do not think that the traffic, as traffic, has been at all bad, for I find the figures show that during the past half year we carried no fewer than 1,422,178 messages. That is not at all a bad half year's business, and it is 69,352 messages in excess of the number transmitted in the same period of last year. Every one knows that an increase of telegraph messages does not necessarily mean an increase of profit. Still, this shows a steady increase, which, as I have said, would have been much larger, but for the circumstances I have mentioned. I think I have, as far as is in my power, accounted for this diminution of one half per cent. in the dividend this half year. Looking forward to the future, I am able to give you some little encouragement, for what I consider a very important feature has just occurred in the working of this Company's business—that is to say, in the Press wires. We lease special wires to the Press, but hitherto that has been confined to the English newspapers. Three of our principal English newspapers are all customers of ours—*The Times*, the *Daily Telegraph*, and the *Standard*—and they have all special wires from us. Now, I am happy to say that the foreign Press, who have never paid to any great extent for telegraphic news, are now coming forward, and we have just concluded an arrangement with *La Reforme*, which is the property of a very enterprising barrister in Paris, who has lately started this paper, and has made arrangements with us for the lease of a special wire. That is a very important feature, and this arrangement is almost certain to lead to others of a similar nature. Indeed, we have already an application respecting another journal. I hope in the course of the next few months that we may see the system of leasing our wires to the Press still further developed. I do not think that I have any further observations to make, but I shall be happy to answer any questions as to the report or accounts.

Mr. C. N. BOYS seconded the motion, which was carried unanimously.

The CHAIRMAN: I have great pleasure in proposing "That, in accordance with the recommendation of the court of directors, the dividend for the half year ending 31st December last at the rate of 18½ per cent. per annum, less income tax, on the capital of the Company be declared, and that it become payable on and after the 1st of March next."

Mr. CAPPER seconded the motion, which was carried unanimously.

Mr. CASTLE SMITH desired to call attention to the subject of the reserves. When he first joined the Company it struck him that the reserves were too small, and that having regard to the capital and the short period that they had to run they would do well to increase the reserves. On the former occasion the reserve had been for a short time 5 per cent. on the gross receipts, and he suggested that it should be 10 per cent., and after friendly consideration and discussion on the subject his suggestion was acted on. On the present occasion, he ventured to submit that the shareholders would be consulting their interests still more if they were to put 15 per cent. to that fund instead of 10 per cent. They had only now a short time to live, unless by-and-by they should have their monopoly renewed. But, assuming that that was not the case, he believed that they had about six years to run, which was only a very short time in which to build up their interests. His opinion was that putting by 15 per cent. of their capital would place them in a very improved position, especially with regard to their future. He believed that if his suggestion were acted upon it would not interfere with their dividend, and that, therefore, they would not suffer in the present, while as regarded the future they would be greatly benefited.

The CHAIRMAN: I am sure we are all very much obliged to Mr. Castle Smith. I consider what he has said is exceedingly good sense, and must commend itself to every shareholder. I have always been in favour of putting by the largest possible amount to the reserve fund, and I was opposed to its being reduced as it was some years ago, and I am happy again to see it at 10 per cent. If, however, the shareholders wish to increase that to 15 per cent. we should be very glad. The more you can put by the better; but, at the same time, there are some shareholders who wish that everything earned should be divided. This is a matter quite for yourselves to decide. I would point out that we could do nothing at this meeting.

Mr. CASTLE SMITH observed that he would suggest that what he had said be regarded as a motion, which should be seconded and dealt with in the usual way.

Mr. CAPPER: As a recommendation to the directors to take it into their consideration?

The SOLICITOR (Mr. Campbell) stated that the resolution was not one which they could pass to have legal effect, but it should be treated in this way, that if the opinion of the shareholders was that 15 per cent. should be put aside the next time, 15 per cent. would be put aside in the next accounts, and if those accounts were then passed it would be done again. If, however, the shareholders would not pass the accounts next time with 15 per cent. in the statement the matter would fall through.

Mr. CASTLE SMITH expressed himself satisfied if the course indicated by the solicitor were acted on.

Mr. CAPPER said he would second the motion if by making the sacrifice of a large dividend they would be greatly benefited.

Mr. RINGS would not express an opinion in any way as to the advisa-

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bility of the step proposed, but suggested that it would be better to leave the question till their next meeting, and then for the directors in issuing their next report to say that in consequence of a desire expressed by some of the shareholders that the reserve fund in future should be 15 per cent. a resolution on that, the next occasion, would be moved to that effect. That would give all the shareholders an opportunity of expressing an opinion on the subject, but he thought it would be altogether hasty to make such a considerable change without giving all the shareholders an opportunity of considering it.

The CHAIRMAN thought that the effect would be very much the same acting on either course.

The Hon. ASHLEY PONSONBY observed that as a director he would prefer that it be regarded entirely as a shareholders' question, and that a resolution should be put instructing the directors to open the question at the next meeting. He quite endorsed what Mr. Smith had said as to the advisability of having a strong reserve fund. Towards the end of their concession they would find it very greatly strengthened, and be put in a much better position, while the market value would also be increased. But at the same time he thought that the shareholders should give an instruction to the directors as to putting 15 per cent. to the reserve in the next report.

Mr. SMITH remarked that the question might then be argued on the report.

The Hon. A. PONSONBY assented, adding that it would not involve any dispute as to the accounts.

Mr. RINGS said that the increase from 5 to 10 per cent. which was moved on a previous occasion, he considered very reasonable indeed, but he thought it might be a question with many of the shareholders whether they might not think that taking 15 per cent. out of the gross profits was going too far, therefore he suggested that every shareholder should have an opportunity of expressing his opinion. He asked whether some confusion would not be created in the accounts if 15 per cent. were deducted, and then the shareholders did not assent to the proposal.

The SECRETARY replied in the affirmative.

Mr. RINGS moved as an amendment, "That the further consideration of the subject be adjourned to the next half-yearly meeting."

The CHAIRMAN, in reply to a question, stated that at the expiration of their monopoly all their property, including the wires, would belong to the Company. The cables, too, were in excellent order, and they would be a very valuable property should they be sold at the end of the six years, and he admitted that in keeping their cables in an efficient condition they were strengthening the reserve.

Sir THOS. DAKIN, reverting to the proposal to increase the reserve fund, said it was one as to which the shareholders generally should be consulted. He seconded the amendment.

The CHAIRMAN said that the resolution which had been moved was to the effect that 15 per cent. should be included in the next report as the appropriation of the reserve fund and shareholders might then accept or reject it. If they adopted the resolution, and the shareholders did not approve the increase of the appropriation to the reserve fund, it would throw the accounts into confusion as they would have been prepared with the view of putting 15 per cent. aside. He was in favour of adding to the reserve fund, but he thought it would be better to act on the amendment so as to give all the shareholders notice, when it might be discussed at the next meeting, and if they approved it it would be adopted at once. After some further discussion on the point the amendment was passed as follows: "That due notice be given to the proprietors in the next half year that for the future 15 per cent. of the gross receipts as from the first of January, 1883, be added to the reserve fund, instead of 10 per cent."

A vote of thanks to the chairman concluded the proceedings.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

Report of the directors to be submitted to the members at the nineteenth ordinary meeting, to be held on Tuesday, the 27th day of February, 1883, at one o'clock precisely. The directors have the pleasure to submit their nineteenth annual report to the members. The accounts for the year show a net profit of £92,260 13s. after charging the interest on the debentures. To this sum must be added £60,394 12s. 9d. brought forward from last year, making a total of £152,655 5s. 9d. From this amount is deducted the interim dividend of 5 per cent., paid July 18th, 1882, amounting to £22,410, leaving £130,245 5s. 9d. to be dealt with. Of this sum the directors propose to distribute a dividend of £1 16s. per share, absorbing £67,230, being at the rate of 15 per cent., and making, with the amount already paid, a total dividend for the year of £2 8s. per share, free of income-tax, leaving £63,015 5s. 9d. to be carried forward to the next account. The operations carried out during the year 1882 have been as follow:—(A) In the early part of the year a cable 550 miles in length was laid, under a concession from the Austrian Government, between Corfu and Trieste, forming part of the Eastern Telegraph Company's system. (B) The German Union Telegraph Company's cable was repaired, in the North Sea, between Lowestoft and Greetseil. (C) The laying for the German Union Telegraph Company of a cable between Valentia, in Ireland, and Greetseil, in Germany, amounting to 776 miles, was completed in April. (D) 254 miles of cable were manufactured for the Western and Brazilian Telegraph Company, and laid in April between Ceara and Maranham, on the Brazilian Coast. The Brazilian Submarine Telegraph Company's cable, off Pernambuco, was at the same time repaired, and the shore end relaid. (E) Between the months of May and September extensive repairs were effected in the Anglo-American Telegraph Company's French Atlantic cable between Brest and St Pierre, in depths up to 2,000 fathoms, after a submergence of thirteen years. (F) In the month of August the Eastern Telegraph Company's cable between Porthcurno and Lisbon was repaired in a depth of 2,700 fathoms, and a cable for the same Company (234 miles in length) was manufactured and laid between Malta and Tripoli in October. (G) During the month of October the Brazilian Submarine Telegraph Company's cable between Lisbon and Madeira was duplicated, 663 miles of cable having been manufactured for this purpose; and the Lisbon shore end of the original cable was relaid. (H) A cable, 965 miles in length, has been manufactured for the Eastern Extension Telegraph Company, which will be laid in the China Sea between Hong Kong and Shanghai. The factories at Wharf-road and at East Greenwich, together with the Company's ships, are in efficient working order. The steamship "Calabria" was chartered by the Government for several months during the year for the conveyance of troops and horses to and from Egypt. The retiring directors are Lord Alfred Paget and Mr. G. W. Campbell, who, being eligible, offer themselves for re-election. It will be necessary for the meeting to appoint auditors for the ensuing year. Mr. John Gane (of the firm of Messrs. Gane and Jackson) and Mr. James Glegg (of the firm of Messrs. Quilter, Ball, and Co.), who retire, offer themselves for re-election.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES FEB. 21.		BUSINESS DONE WEEK ENDING FEB. 21. Highest.		Lowest.
Anglo-American	49½,	50½	..... 50½	.....	49½
Do. Preferred	80½,	81½	..... 81½	.....	80½
Do. Deferred	18½,	18¾	..... 18¾	.....	18¾
Brazil Submarine	12⅜,	12⅝	..... 12⅝	.....	12 7-16
Cuba	9½,	10½	..... --	.....	—
Do. Preference	16½,	17½	..... —	.....	—
Direct Spanish	6½,	6¾	..... 6½	.....	6¼
Do. Preference	16,	17	..... —	.....	—
Direct United States Cable	12½,	12⅝	..... 12⅝	.....	12 3-16
Eastern Telegraph	10⅞,	11¼	..... 11 1-16	.....	10⅞
Do. 6 per Cent. Preference	13,	13½	..... 13½	.....	13½
Do. 5 per Cent. Debentures, 1899	103,	106	..... —	.....	—
Eastern Extension	11½,	11¾	..... 11¾	.....	11⅝
German Union	10½,	11	..... —	.....	—
Globe Telegraph and Trust Company.	6½,	6¾	..... 6 13-16	.....	6¾
Do. Preference	12⅝,	12⅞	..... 12⅞	.....	12⅞
Great Northern	12,	12¼	..... 12¼	.....	12 1-16
Indo-European	32,	33	..... —	.....	—
Mediterranean Extension	1⅞,	2⅛	..... 1⅞	.....	1⅞
Do. Preference	7,	8	..... 7⅞	.....	7⅞
Reuter's	10½,	11	..... —	.....	—
Submarine	260,	265	..... —	.....	—
West India and Panama	1⅛,	1⅛	..... 1⅛	.....	1 5-16
Do. 1st Preference	7,	7½	 7	.....	7
Western Brazilian	7⅞,	8	..... 7⅞	.....	7⅞
West. Union 7 per Cent. 1st Mortgage	122,	126	..... —	.....	—
Do. 6 per Cent. Sterling Bonds	102,	105	..... —	.....	—

TELEPHONES.

Consol. Telephone and Maintenance	⅞,	1	..... ⅞	.....	⅞
Oriental	¼,	½	 12-16	.....	½
United Telephone	11,	11½	..... 11 11-16	.....	11⅜

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	4⅜,	5⅛	..... 5⅛	.....	5
Do. (fully paid)	8,	9	..... 9⅛	.....	8⅛
Hammond Light	3,	3½	..... 3⅜	.....	3 3-16
Eastern Electric (£5 paid)	1,	1½	..... —	.....	—
Pilsen, Joel, and General Electric	½,	1	..... —	.....	—
Swan	2,	2½	..... 2 3-16	.....	2 3-16
Maxim-Weston	¼,	½	..... ½	.....	⅜

THE LONDON PLATINO-BRAZILIAN TELEGRAPH COMPANY (Limited)
(RIVER PLATE and BRAZIL TELEGRAPH COMPANY).

NOTICE is hereby given that the HALF-YEARLY COUPONS which fall due on the 1st March, 1883, of £100,000 Seven per Centum Debentures of the River Plate and Brazil Telegraph Company will be PAID by Messrs. Glyn, Mills, Currie, and Co., 67, Lombard-street, in the City of London, bankers, on and after the 1st day of March, 1883, less income-tax. The Coupons must be left with Messrs. Glyn, Mills, Currie, and Co., for examination three clear days before the same can be paid.

By order,
WM. PAYTON, Secretary.

No. 66, Old Broad-street, E.C., London,
22nd February, 1883.

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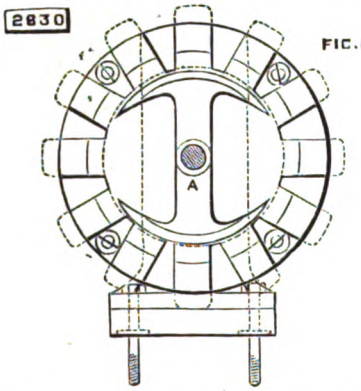
RECENT INVENTIONS.

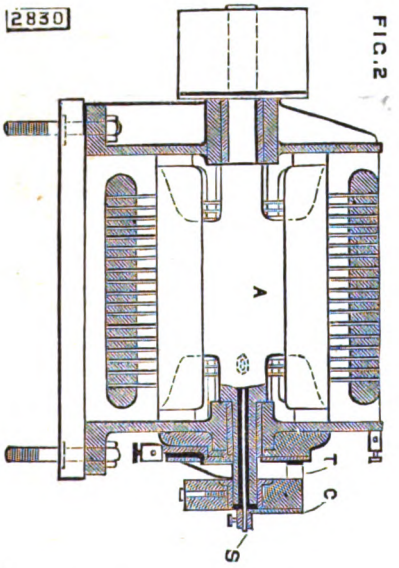
ABSTRACT OF SPECIFICATIONS.

830. Improvements in the Construction and Government of Electro-motors, &c., *Professors W. E. Ayrton and J. Perry, Finsbury.*—15*th June*, 1882. 8*d*.

One form of the invention is shown in Figs. 1 and 2. A is a rotating field magnet formed of soft iron or other material and wound with wire in coils, which are nearly parallel to the axis. This rotates inside a Pacinotti ring. In the



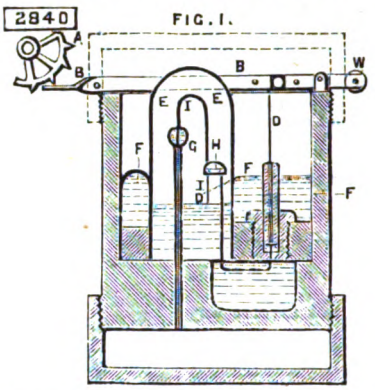
present case one end of the wire on the bobbin is fastened to the iron, and the other end passes insulated through a hole in spindle S, where it is connected to one of the rubbing brushes T. There are twelve coils on the ring, and their rods



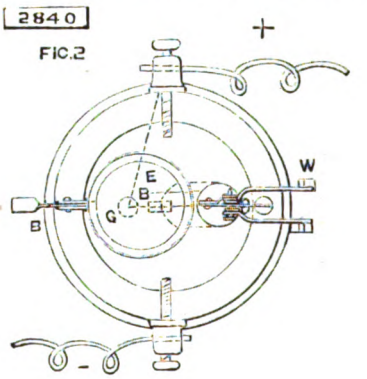
are joined up to the pieces C of the commutator as in the Gramme ring. In addition to the above machine, the inventors claim an arrangement by which the relative positions of the brushes and field magnet may be altered; another arrangement by means of which the relative positions of the commutator and the Pacinotti ring may be altered, &c., &c.

2840. Apparatus for the Measurement and Regulation of Velocity, *H. S. Hele Shaw, Bristol.*—16*h June*, 1882. 6*d*.

According to this invention the moving body, whose motion is to regulate that of another, imparts impulses to one end of a lever or frame, the other end of which communicates with a space from which oxygen and atmospheric impurities are excluded, a suitable purified gas being substituted. This space is separated from the outer air by mercury, through which a portion of the lever or frame, or a wire attached thereto, passes, and in which it works without appreciable friction. In the isolated space, but insulated from the mercury below, is a capsule of mercury, in which the wire attached to the lever dips at every impulse, and thus establishes electrical communication between the two portions of mercury, and so with two wires communicating with a motor whose motion is to be regulated; thus oxidation of the electrodes is almost altogether prevented.



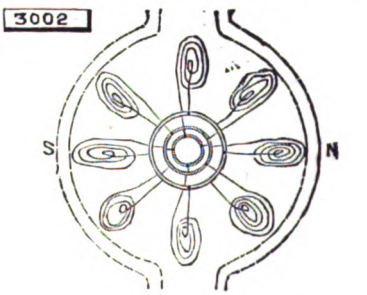
Figs. 1 and 2, which are sectional and plan views of the apparatus, taken with the above description, will explain the invention. A is the escapement wheel of a standard clock, whose motion is to regulate that of another body. B, the lever;



D, platinum wire passing into space filled with purified gas, E; F, mercury separating E from outer air; G, capsule of mercury; H′, glass junction, joining wire D with wire I, one end of which dips in G.

3002. Improvements in Dynamo-electric Machines, *P. Jensen, London.*—24*th June*, 1882.—*(A communication from D. A. Schuyler and F. G. Waterhouse, New York.)* 8*d*.

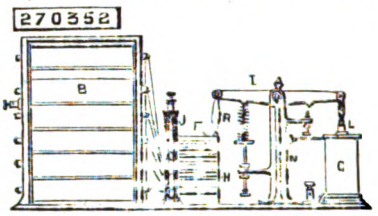
This relates to a novel arrangement of armature coils, &c. The coils are divided into sets of four, those in each set being disposed symmetrically with relation to one another in such a way that each coil of a set is placed at an angle of ninety degrees from its two neighbouring coils in the same set, and diametrically opposite the re-



maining coil of the set. Each set is provided with a separate commutator ring, and one end of each helix in a set is connected to a separate plate of the commutator. With the arrangement of field of force poles employed, diametrically opposite bobbins would be connected to diametrically opposite segments. The remaining ends of the coils are connected or in permanent electrical connection with one another. Commutator brushes are so applied that each bobbin is connected to the brush during its movement from one neutral point to the other. The figure illustrates the manner of dividing and connecting the bobbins to one another and to the commutator.

270,352. Device for Controlling Electrical Currents, *Charles J. Van Depoele, Chicago, Ill.*—*Filed July* 27*th*, 1882.

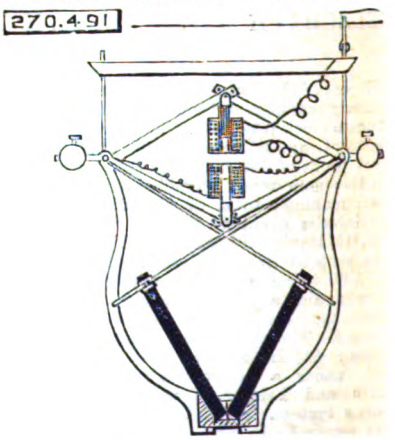
Claim.—(1) The coils B, permanently connected at their outer ends to one of the branch conductors of a multiple arc circuit, and a corresponding series of superposed insulated contact pieces F, each connected to the inner end of one of said coils, and provided with contact points H, and a support, J, provided with adjustable downward acting spring and suitable set screw, in combination with the lever I, provided with link R, electrically connected to the upper one of said contact pieces, the solenoid G, permanently connected to the other conductor of the branch, the core L, and suitable



wire connecting said solenoid and lever, and adapted to elevate or depress said core and lever to separate or connect the contact pieces F, and thereby regulate the branch current passing through the device in response to the fluctuations of the main current, substantially as set forth. (2) In combination with the wires of the external circuit the coils B, contact pieces F, and support J, the solenoid G, standard N, lever I, core L, and suitable connecting wires, all located in and forming part of a branch of a main circuit, an adjustable stop, a regulating tension spring connected to the stop and the said lever I, and suitable adjusting screw, substantially as shown and described.

270,491. Electric Light, *H. A. Seymour, Washington, D.C.*—*Filed June* 1*st*, 1882.

Claim.—(1) The combination, with the carbons of an electric light, of blocks of refractory material, against which the carbons rest, or which serve to support the adjacent ends of the carbons, and devices for automatically separating the blocks by the action of the current, substantially as set forth. (2) The combination, with the carbons of an electric light, of blocks of refractory material, against which the carbons rest, or which serve to support the adjacent ends of the carbons, and devices for automatically moving the blocks toward and from each other by the action of the current, substantially as set forth. (3) The combination, with the carbons of



of an electric light, of blocks for limiting the lengthwise movement of the carbons, and devices for automatically varying the distance between the adjacent ends of the carbons, substantially as set forth. (4) The combination, with the carbons of an electric light, of blocks for limiting the feed of the carbons, a solenoid in the main circuit for separating the blocks, and a solenoid in a shunt-circuit for causing the blocks to approach each other, substantially as set forth. (5) The combination, with the carbon, of an electric light and blocks of refractory material for supporting the adjacent ends of the carbons, of arms having said refractory blocks removably secured to the adjacent ends thereof, and electro-magnets for automatically regulating the distance between the end of the carbons, substantially as set forth.

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SLIP

South America.—The cable between Callao and Mollendo is interrupted.

South Australia.—The postal statistics show the receipts for telegrams in this colony to be £42,000 per annum.

Direct Spanish Telegraph Company.—This company's direct cable communication with Spain, *viâ* Bilbao, is now fully restored.

Electric Lighting on Ships.—The steamer "Kate Adams," which plies on the Mississippi, is lighted by means of the Edison system.

Channel Islands.—Telegraphic communication with Guernsey is now restored. The cable between Guernsey and Alderney, however, remains interrupted.

Venezuela.—The land lines in Venezuela being interrupted, telegrams for that country can only be forwarded by way of the West Indies, and thence by post.

Royal Society.—On Thursday last Dr. Frankland, F.R.S., was to read a paper before this society entitled "Contributions to the Chemistry of Storage Batteries."

Royal Institution of Great Britain.—Last night (Friday) Mr. C. Vernon Boys was to read a paper before this institution on "Meters for Power and Electricity."

Electrical Exhibition at Philadelphia.—The Franklin Institute of Philadelphia, U.S.A., give notice of their intention to hold an electrical exhibition in that city during this year.

Provisional Orders.—The applications for provisional orders under the Electric Lighting Act in respect of Rochdale and Stalybridge have been thrown out on standing orders.

The Edison System in Europe and America.—Up to the 20th December last 29,192 Edison lamps were in use in America. Up to the commencement of February 19,536 lamps were in use in Europe.

New Book.—We have received a copy of a translation from the French of the Count du Moncel's excellent little work on the construction of electro-magnets, by Mr. C. J. Wharton. The book is published by Messrs. Spon, of Charing Cross, S.W.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 23rd February, 1883, were £2,276, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

New Company.—The Sperry Electric Light Motor and Car Brake Company of Chicago has recently been organised with a capital of 1,000,000 dollars, to work the inventions of Mr. Elmer A. Sperry in electric lighting and the application of electricity to motors.

An Explanation.—The Electric Carbon Storage and Apparatus Manufacturing Company wish us to explain that the Electric Carbon Company, referred to in our last issue as likely to be shortly wound up, is in no way connected with them, but is an entirely separate company.

West India and Panama Telegraph Company.—The estimated traffic receipts of this company for the half month ending the 15th February are £3,267, as compared with £2,983 in the corresponding period of 1882. The November receipts, estimated at £2,700, realised £2,707.

Society of Telegraph Engineers.—At the next meeting, to be held at 25, Great George-street, on Thursday, March 8th, at 8 p.m., a paper will be read "On Some New Forms of Telephone Transmitters, with a Note on the Action of the Microphone," by John Munro, associate.

Electric Lighting in Paris.—The Magasin du Printemps, in Paris, which was destroyed by fire about two years ago, has been rebuilt on a magnificent scale, and will shortly be opened. It will be lighted on the Jablochkoff system. Three hundred and fifty lamps will be employed.

Electric Lighting in Russia.—The Edison system is in use in the saw mill of M. Johnson at Yväskylä, in Russia. Forty lamps and an E dynamo constitute the plant at present. This is probably the most northerly point to which electric lighting has penetrated as yet; it is between the 62nd and 63rd degrees of latitude.

Electric Lighting for Newington District.—The *Gazette* of Tuesday last contains a notice from the Vestry of Newington, S.E., that they have applied to the Board of Trade for a license under the Electric Lighting Act, 1882, to supply and distribute electricity for public and private purposes in the parish of St. Mary, Newington.

Electric Lighting at Brunn (Austria).—The installation on the Edison system at Brünn Theatre was examined a day or two ago by the archduke. The machines were all set going for the occasion, and everything explained in detail by Mr. Francis Jehl, who has charge of the work. The archduke expressed great satisfaction with the lighting arrangements.

Telegraph Extension in Canada.—A line of Government telegraph is to be constructed from the present crossing of the south branch of the Saskatchewan River to Prince Albert. The promise to do this is, however, says the *Colonies and India*, made conditionally on the residents in the districts to be benefited contributing the required poles for carrying the wire.

To be Wound Up.—The Brush Electric Light and Power Company of Australasia is to be voluntarily wound up. It has sold all its patent rights to the Australasian Electric Light Power and Storage Company. Creditors should send in their claims before the 10th April to the liquidators, Mr. F. S. Isaac, 22, Great Winchester-street, E.C., and Mr. C. L. Wade, 18, Old Broad-street, E.C.

Prevention of Twist in Cables—A patent has recently been taken out by Mr. G. E. Vaughan for foreign inventors, in which a means of preventing the twisting asunder of cables when being made or laid is described. The inventors propose to wind the insulated core with alternate left and right-handed layers of yarn, one over the the other. The patent is dated 4th July, 1882, No. 3142.

M. Deprez's Experiments.—At the meeting of the French Academy of Sciences on the 19th February, M. Tresca read a paper on the recent experiments by M. Deprez at the workshops of the Northern of France Railway, when he resumed the Miesbach-Munich experiments in the transmission of power by means of electricity. According to M. Tresca, a machine of 6·31 h.-p. installed in the Northern Railway Station actuated another machine by a current transmitted through 8,500 metres of wire. The power received on the brake was 2·03 h.-p., and the return was consequently ·326.

Sunderland University Extension Classes.—The report of the examiner on the results of the recent course of

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lectures on electricity and magnetism in connection with the University Extension Classes in Sunderland is very favourable. He states in his report "That for a scientific course of lectures to university students the syllabus scarcely admits of improvement." Nineteen students entered for the examination, and of these seventeen passed. Seven were recommended for special distinction—these were John Burns, John H. Cox, Edith Edmunds, G. A. Lax, G. H. Shevill, Maria Stephenson, and William F. Vint.

The Maxim-Weston Electric Company.—Rumour has of late been busy in City circles with the name of this company. Amongst other things we have heard it whispered that the shareholders are not over satisfied with the way in which the business of the company has been conducted, and that they have or will appoint a committee of investigation. The company certainly has not had an air of prosperity about it lately, in fact it seems to have lost the vigour it once had. There must be a reason for this. We have no doubt that the committee of investigation will arrive at a satisfactory solution of the reason why the company has made so little headway recently.

Underground Wires in New York.—According to a New York contemporary, the Western Union Telegraph Company have decided to begin in earnest the work of putting all the wires of the company in this city underground. The first underground main will extend from the company's building at Broadway and Dey-street, up Broadway to 23rd Street. The wires, it is said, will be laid in a tube large enough to contain 200 wires. The contract for this primary line has been given out, and work upon it will begin, it is promised, as soon as the weather will permit. The right to use the streets for this purpose was secured a few years ago. It is promised that, if the undergound system adopted works well, it will be extended to all parts of the city.

Electric Light for H.M.S. "Malabar."—We recently described and illustrated the method that had been adopted by the Swan United Electric Light Company in fitting up H.M.S. troopship "Himalaya" with their lamps. A sister trooper, H.M.S. "Malabar," is also to be lighted by incandescent lamps, the work in this case having been given to the Edison Electric Light Company. The total number of lamps to be employed will be 104 A or 16-candle, and 269 B or 8-candle, of the well known Edison type. The current will be supplied by two L dynamos, which will be driven by two direct acting Brotherhood steam engines. The work is to be finished by the end of April next. Lieutenants and other unfortunates condemned to pass their nights and part of their days in what is known as the "Pandemonium" on board these troopers, which encounter such roasting temperatures as are peculiar to the Red Sea and thereabouts, will bless the names of Edison and Swan.

Insulating Wire.—A new method of insulating wire for electrical purposes has recently been adopted by the Triplex Insulated Wire and Rubber Company. The method consists in tinning the wire; it is then covered with a layer of soft rubber, around which a strip of soaked linen is wrapped, and which in turn is covered by an outer layer of thick, hard rubber. For underground wires another layer is added. The process of manufacture of this insulated wire is very simple, all the layers being put on in one operation by means of machinery, thus making it possible to furnish a comparatively cheap article. The wire is fed from a reel into a groove cut upon two steel rollers heated with steam, and simultaneously two strips of soft rubber, each more than covering one half of the wire. The excess of rubber is stripped. The coated wire is then automatically wrapped with soaked linen strips, and is carried to a second set of rolls, where two strips of hard rubber are united around it to a third coating.

Insulating Compounds.—Two patents have been taken out recently for insulating compounds. The first is numbered 3175, and was taken out, on the 5th July last, by Messrs. Bottomley, Barry, and Lundy. The inventors dissolve leather with dilute muriatic and chloride or sesquichloride of iron, or with caustic soda or other suitable solvents, which solvents may be expressed therefrom or neutralised therein as convenient. They also claim the use of animal, mineral, or vegetable pitch combined with raw or boiled linseed or other drying oil, and either with or without dissolved leather, osseine, glues, gutta percha or gum, as an insulating material. The second patent is numbered 3176, and was taken out by Mr. Mackay on the 5th July last. This invention consists in combining by heat at 100 to 212 deg. Fah. mineral wax, such as paraffin or ozokerit wax, vegetable tar (wood tar), shellac, and asbestos, in the proportions of—wax, 1; wood tar, 24; shellac, 32; asbestos, 32. The inventor also proposes to employ this composition for forming moulds for electro-plating purposes.

Electric Lighting in Bath.—A part of the spacious premises of the Merchants' Alliance Supply Stores in Stall-street, Bath, is now lighted by means of Brush lamps. The ground floor is all that is at present completed, and this is divided into three departments—the shop for general tailoring and hosiery, the second department for mechanics' clothing, and the third for boots. All these are lighted by the Brush system. There are altogether six arc lights, four inside and two outside the premises, one of the latter being placed on the top of the house and fitted with a "head light reflector" similar to the reflectors used on the front of the locomotives in the United States, and capable of throwing a ray of light for a half-mile. These lights are supplied by a No. 5A Brush arc light machine, driven by a six horse-power horizontal steam engine erected by Messrs. Adlam and Son, of Bristol. The lamps and machines have been erected by the Great Western Electric Light Company, under the superintendence of Mr. P. Jolin, their electrician.

Electric Lighting at Parkstone Station.—The railway station and hotel at Parkstone, near Harwich, belonging to the Great Eastern Railway Company, are to be lighted by incandescent lamps. The Swan United Electric Light Company will carry out the work. Two hundred and fifty Swan lamps of 20 candle-power are to be fitted up to begin with. The current will be supplied by 55 four horse-power Faure-Sellon-Volckmar accumulators, as made by the Electrical Power Storage Company. The fittings throughout are to be supplied by Messrs. Laing, White, and Wharton, of Holborn. Parkstone is a very important station, as all the Continental traffic of the Great Eastern Railway Company goes through it. No doubt the new lights will be much appreciated by travellers using the company's hotel, particularly if they happen to have had a rough sea voyage. The cool and fresh atmosphere afforded by the use of the electric light, as compared with the vitiated and burnt air which is peculiar to rooms in which gas been burnt, will, to passengers lately under the influence of *mal-de-mer*, have a particular charm.

The Telephone in Dundee.—The local authorities in Dundee are going in extensively for the telephone. The police commissioners have instructed the National Telephone

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Company to run eighteen "private" wires from their central station, four to branch stations, one to the chief constable's house, one to the deputy chief constable's house, and one to the police surgeon's house. The other wires will run to the firemen's houses, gas commissioner's office, water manager's office, and other places. The same company are also about to erect private wires from the water manager's office to the two reservoir keepers' houses, and to the manager's private house. Another private wire is to run from the police clerk's office to the burgh engineer's office. The Board of Guardians are going to connect their workhouses and the parochial offices with the Company's Central Exchange in Panmure-street, and, finally, all the municipal offices are to be coupled up to the exchange. The work will be carried out under the superintendence of Mr. Frank Lumley, C.E., the company's electrician and manager.

Telephonic Repeaters.—Mr. T. D. Lockwood, well known in America as an authority on telephonic matters, writes as follows with reference to Mr. A. R. Bennett's telephonic repeaters, recently described and illustrated in our columns:—"As a matter of fact, there is very little new in this device. It was certainly used in the autumn of 1879 by Mr. Thomas A. Watson and myself, the object we had in view being the same as that of Mr. Bennett, viz., the communication of the articulating currents inductively from a metallic to an earth circuit, or *vice versâ*. The only reason we did not continue this, and introduce the plan universally, was that we found that on nearly all the lines the increased loudness attained on the direct circuit compensated so nearly the interfering noises that there was no sufficient advantage apparent in the use of the coils to warrant their introduction. To any thinking electrician who has examined the Blake transmitter, this plan of inductive repetition would be at once suggested, since in every such instrument it is used, the electrical undulations in the primary coil being caused to induce similar currents in the secondary."

The United Telephone Company.—The chairman of this Company has issued a circular to the shareholders, in which he summarises the recent legal proceedings which were taken to uphold the Company's patents. In referring to the last trial, viz., the appeal of Messrs. Harrison, Cox-Walker, and Co., against Mr. Justice Fry's decision of May last, he alludes to the possibility of an appeal to the House of Lords by the above-mentioned defendants, but expresses the confidence felt by the directors that even in that eventuality they will gain the day. The latter part of the circular contains some interesting statistics of the progress made by the Company. It states that, on the 28th February, 1881, the number of subscribers to the London Exchange was 845; on the same date of 1882, this number had increased to 1,505; and on the 28th February, 1883, to 2,541. As showing the use made of the Company's system, the circular further states that the total calls for the five days included between the 15th and 21st February, 1881, were 22,256, or a daily average of 4,451; in 1882, for the same period, they amounted to a total of 48,586, or a daily average of 9,717; and for the same period in 1883 the total was 95,108, giving a daily average of 19,021.

Magnetic Storms and Data.—We take the following from the report of the Kew Committee of the Royal Society for the year ending 31st October, 1882:—"Three magnetic storms, or periods of considerable disturbance of the needles, have been registered during the year; viz., on April 17th and 20th, and on October 2nd. All were accompanied by auroral displays, but these were only observed in this country on the latter date. The following is a summary of the number of magnetic observations made during the year:—Determinations of horizontal intensity, 33; dip, 138; absolute declination, 28. At the request of the Polar Committee of the Royal Society, a number of old magnetic instruments were removed out of store, and after repair, packed and delivered to Captain Dawson, R.A., who has been entrusted by the Government with the charge of a temporary observatory established in connection with the international system at Fort Rae, Great Slave Lake, N.W. America. Other instruments were lent to the Rev. S. J. Perry, F.R.S., for use during their residence in Madagascar for the observation of the transit of Venus by a party under his direction; and a third set were prepared for Dr. Ristori, who projected an expedition to Iceland, but has not yet started for that country."

Electricity; its Characteristics and Uses.—The second lecture under this title was delivered by Mr. J. H. A. Macdonald, Q.C., before the members of the Edinburgh Philosophical Institution on Friday week. Beginning by referring to the relation between magnetism and electricity, the lecturer explained and illustrated the different characteristics of magnets—some of these being that the power they possessed developed itself at the ends only, and in opposite degrees at each end; that magnets could be produced by electricity; and that in electrical magnets their power was displayed in certain regular lines of force. The principle upon which dynamo machines generated electricity was also explained, as was likewise the system of accumulating electrical energy by storage batteries after the Faure-Sellon-Volckmar method. Turning to the uses of electricity, the lecturer explained the telegraph, telephone, microphone, the various kinds of electric lamps, &c. This lecture, like the preceding one, was illustrated by numerous diagrams, apparatus, and experiments. The portion of it dealing with electric illumination was illustrated by a number of Lane-Fox incandescent lamps, supplied from 25 accumulators of the Faure-Sellon-Volckmar patent, made by the Electrical Power Storage Company, London. A 1,500 candle-power arc "Brush" lamp, fed by a dynamo placed in Messrs. Constable's printing establishment, near at hand, was suspended from the roof of the hall.

Electrolytic Estimation of Zinc.—An abstract of a paper by A. Millot, in the *Bull. Soc. Chim.*, Vol. 37, 2nd Series, pp. 339-41, was given in a recent number of the *Journal* of the Chemical Society. According to the author, the process is as follows:—"2·5 grams of the mineral are dissolved in 50 c.c. of hydrochloric acid, and a small quantity of potassium chlorate is added to the boiling solution in order to precipitate the iron. If the mineral contains much silica, it is previously evaporated to dryness with hydrochloric acid. The liquid is cooled, diluted, and mixed with 100 c.c. of ammonia, and 50 c.c. of a saturated solution of ammonium carbonate in order to precipitate the lead and calcium. The liquid is diluted to 500 c.c., filtered, and 100 c.c., corresponding to ·5 gram of the mineral, and containing from ·2 to ·3 gram of zinc, are mixed with 1 gram of pure potassium cyanide and placed in a beaker, in which is suspended a cylinder of platinum gauze, which acts as the positive pole, and a platinum cone like that in Riche's apparatus, which acts as a negative pole. Two Bunsen cells or a Clamond thermo-electric pile of 150 elements may be used to effect precipitation, which is complete in about ten hours. The firmly-adhering deposit is washed with water, then with

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alcohol, and dried. If the mineral contains copper the latter is deposited with the zinc. The deposit on the cone must in this case be dissolved in nitric acid, and the copper precipitated from the acid solution. If cadmium is present it must be removed by treatment with hydrogen sulphide. The potassium cyanide should be used in the proportion given above. If more is added, the metal is deposited very slowly, whilst if less is added the deposit of zinc is not adherent. Any action on the electrodes may be prevented by mixing the solution with ammonium acetate or nitrate. The latter, however, retards the precipitation of the zinc."

Telegraph Clerks' Grievances.—A largely-attended meeting of telegraph clerks was held in the Glasgow Christian Institute on Saturday night last. After some discussion, the following resolution was proposed :—"That this meeting is deeply dissastisfied with the scheme of revision applied in 1881 to Her Majesty's Telegraph Department, and cannot regard as final any scheme which fails to satisfy the claims put forward in the petition of the postal telegraph clerks of the United Kingdom to the Postmaster-General in 1881." The resolution was seconded and carried unanimously. Another resolution was proposed and seconded, as follows :—"That this meeting calls upon the central committee of the Postal Telegraph Clerks' Association to use every legitimate means to obtain a concession of the claims put forward by the postal telegraph clerks of the United Kingdom in their petition of 1881." The resolution was adopted unanimously. It had been considered wise to give the scheme lately inaugurated a fair trial, but as it had been found in many details to fall short of what was deemed a fair and final settlement of the grievances complained of, the time had now come to renew the agitation and to use all legitimate means to obtain the claims formerly laid before the Postmaster-General. A resolution expressing gratification at Mr. Fawcett's recovery from his recent illness was afterwards passed, and the proceedings were brought to a close.—A meeting of telegraph clerks was held in Dublin on Saturday, at which resolutions were adopted expressing dissatisfaction with the late revision of salaries, and expressing conviction that no scheme could satisfy the service that was not based on the united petition of 1881, and asking for the appointment of a select committee to inquire into their grievances. A motion was adopted strongly condemning the action of the Glasgow authorities in suspending the local secretary for posting a notice convening a meeting of his fellow clerks, and sympathising with him.

The Elphinstone-Vincent Dynamo.—A series of experiments were made with the Elphinstone-Vincent dynamo, on the evening of Wednesday, February 21st, at Messrs. Unwin Brothers' printing office, the Gresham Press, Little Bridge-street, Ludgate-hill. A large warehouse on the first floor was fitted with 350 Swan incandescent lamps, each of 20 candle-power, suspended from the ceiling. Lord Elphinstone explained that the machine was capable of driving 416 Swan lamps, but owing to delay only 350 could be set up. Mr. Vincent briefly explained the construction of the machine, after which several experiments were shown, amongst others a length of about 40ft. of galvanised iron wire, $\frac{1}{8}$in. thick, was rendered red hot. As the heat increased the zinc burnt off in brilliant coruscations, the heat kept on increasing up to whiteness, and finally the wire fused, parts of it as it struck the floor breaking up into brilliant globules of melted wrought iron. Lengths of steel, and also copper wire, each became in turn incandescent, the steel being fused. The current was then made to run through a coil of iron wire immersed in a glass vessel holding three quarts of water. Instantly there was a hiss as when a red-hot poker is plunged into water. This was followed almost immediately by steam; in half a minute the water boiled, and before a minute had elapsed half the contents of the vessel was on the floor. An ordinary steel flat file, 1in. by $\frac{1}{4}$in., was then placed instead of one of the carbons in an arc light, and the current being passed through, the end of the file was melted and consumed like a tallow candle in a fire, throwing off a shower of sparks with a Catherine-wheel-like effect. The experiments concluded by the lighting up of a very powerful "Search Light," as used by the Navy, the carbons of which are $1\frac{1}{4}$in. in diameter, capable of giving a light equal to 100,000 candles. The whole of the mechanical arrangements were carried out by Mr. Arthur Rigg, engineer to Lord Elphinstone and Mr. Chas. W. Vincent, under the superintendence of Mr. S. G. Wilmott, his manager, who also assisted Mr. Vincent with the experiments. The motive power used for driving the dynamo machine was supplied by one of Rigg's patent high-speed engines, capable of developing 60 indicated horse-power. A description and illustration of the Elphinstone-Vincent dynamo appeared in our issue of Jan. 20.

Electric Lighting for Workshops.—In the course of a discussion on Mr. A. Jamieson's paper on electric lighting for workshops recently read before the Institution of Engineers and Shipbuilders in Scotland, some interesting statements were made by various gentlemen who had had practical experience of the working and cost of the electric light. Thus, Mr. A. C. Kirk, of the firm of R. Napier and Sons, stated that his firm had been one of the first in Glasgow to adopt the light. They were using Brush arc lamps in their yard and elsewhere, and were well pleased with them. As to the cost, he stated that he had "found that while burning the lamps three hours a day, the cost of each lamp per week was about 5s. 7d. That was counting twelve lights. He put down 1s. 6d. for the cost of maintenance, and the half of a man's wages for attendance—15s. per week; cost of carbons, 8s. 6d.; and after allowing for the depreciation of the Brush machine, the whole cost was £2 1s. 9d., or 3s. 7d. each for the twelve lamps per week. If the lamps were kept burning 49 hours a week, the cost per lamp would be about 6s. per week. In fact, the increased number of hours did not add very much to the cost, beyond the price of the carbons." Mr. Dick, of the Newton Steel Works, stated that they had been using 14 or 15 Brush lamps. "He had made up a rough estimate of the cost of lighting the works for the six months ending 31st May, 1881, and the six months ending 31st May, 1882. The first great falling off was in the quantity of naphtha used. The cost in 1881 was £172 1s. 6d., and in 1882 £102 8s. 10d. In 1881 the lamps used cost £15 4s. 11d., and in 1882 £2 5s. 6d. Altogether the saving for the six months was £89 3s. 5d. In the foundry alone there was a saving of £19 6s. 1d. Against the total saving there would have to be put £81 6s. for labour and upkeep. He had not been able to form an exact estimate as to the cost of the coal used, but thought that £8 would be pretty near the mark. Although the total saving was but £19 1s. 6d., there was a further profit in the superiority of the work turned out and the amount of it that the men could get through. The lamps were not quite so steady as could be desired, but this was probably owing to the dust that was flying about the works." Mr. Gilchrist (of Barclay, Curle and Co.) said his firm had used the electric light last winter, and through the extra illumination they got a great deal of extra work done by the men, and it was without doubt a capital light for factories, workshops, and large open spaces.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XV.

In accordance with the plan marked out at the commencement of these papers, we have introduced to the learner's notice the operations which he would be expected to master as nearly as possible in the order in which he would meet with them in practice, and if he had intelligently gone through the course explained in the preceding numbers he would by this time be in a position to afford useful service in the testing room. With one exception only we have given sufficient instruction to insure his position up to a certain point, even if we extended it no further. This exception is important, and our plan would lack a necessary feature if we intended it to be permanent; we refer, of course, to the working out of the tests, reducing the observations to actual figures, and obtaining particular values for the indications otherwise merely general. In order to explain this part of the subject clearly and thoroughly we must consider the construction of the formulæ which govern the course of calculation; and it appeared safer to make this a separate branch or section than to interweave it between the different tests, a course invariably involving repetition; whilst there is another strong reason for so acting, viz., that in practice the learner will, in nine cases out of ten, acquire the ability to work out the tests mechanically. He will be shown how to add or subtract certain logarithmic numbers in different instances, and can be trusted to present correct results without really understanding the *rationale* of his work. We make these remarks lest we should appear to neglect a most important item in our programme. Before, however, entering on this subject, there are other forms of test for consideration which the learner ought to acquire. They are not so generally used in the testing room during manufacture as those already explained, but are most conveniently introduced at this point, as it will be seen later on that the day will come when one or all of them may be necessary, and no time or opportunity may be afforded for learning them properly. These tests relate severally to copper resistance (C.R.), inductive capacity (I.C.), and insulation resistance (I.R.), and will be considered in this order, as were those in the preceding numbers. We commence with the test for C.R., by "reproduced deflection." It is rarely necessary to employ this test where both ends of the cable are available, and as a rule it is used either during or after submergence. In this case one pole of the battery is to earth as well as the further end of the cable. When taken at the works it can be done in this way, or without using earth connection at all. Mr. Kempe in his work on "Testing" commences by introducing this kind of test, and remarks that, though very simple, it is inferior to no other in point of excellence of principle. This is true, and as the author shows through the whole chapter, it is very comprehensive and useful. But the employment or otherwise of this test depends on circumstances which are not detailed by him, and the conditions are not the same when it is used as there suggested, as they are when taken with a submarine cable. Moreover, without closer explanation than Mr. Kempe has given, a beginner would not succeed in getting any sufficient results, at any rate with the appliances which he finds in the testing room. However, Mr. Kempe does not say his remarks refer solely to submarine cables, nor does he specify the particular instruments to be employed. In considering this test as taken during manufacture we must necessarily omit certain features which are only present during the operation when performed on a submerged cable. These points will come before us at the proper time. The principle of the test is as follows:—We have an *unknown* resistance whose amount we desire to measure, and instead of directly balancing a *known* resistance against this, we measure first the unknown (or cable) resistance by passing a current through a galvanometer in circuit with it, and noting the deflection, and afterwards substitute a variable resistance in its place, and arrange this until the same deflection is reproduced. To avoid needless waste of time the amount of resistance introduced in the place of the cable is chosen as nearly as possible equal to that of the section to be tested, which must be guessed at or rather estimated by means which the learner now readily understands. We may compare this mode of finding the C.R. with the Wheatstone bridge test by referring to the operation of weighing some body or substance.

Achieving a balance with a pair of scales illustrates the latter, and supposing some disturbing influence to prevent our using them in another case, the former method may be paralleled by imagining we have an apparatus as a steelyard without the marks appropriate to the different weights, and, attaching first the body to be weighed, that we mark the place to which the index reaches by the pull on the spring, and then substitute different known weights till the index touched the same mark. The weight is then known to be that of the piece which produced this effect, just as the amount of resistance by which the former deflection was reproduced is the measure of the unknown or cable resistance first put in circuit. It is considered by authorities a superior mode of C.R. testing, partly for its simplicity; and, certainly, under those circumstances in which it is more generally employed, it affords results which it might be almost impossible to achieve with the Wheatstone bridge. As regards the connections for the test nothing can be more simple. The principle is the same as that of the insulation test already illustrated, but there is this difference with regard to the object of measurement—the resistance with which it is concerned is immensely small in the one case compared with that involved in the other, and the standards of comparison in the two cases are very different in their proportion to that which they determine. These points are important in connection with the arrangement of the galvanometer employed in the test now before us; and the fact that the correctness of the result depends partly on the sensitiveness of this instrument is an additional reason for commencing the operation by attending to this arrangement.

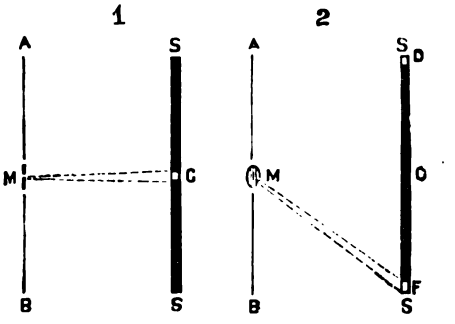

FIG. 33.

As the galvanometer is very sensitive, and the resistances to be measured are comparatively small, the current passing through them from a small number of cells will produce a considerable swing of the mirror, so that unless we had an immensely long scale we should have no readable deflection under the ordinary position of the mirror and magnet within the coil. The learner understands that their normal position, or that when no current is passing through the instrument, is in the same plane as that of the coil surrounding them; and that a line drawn, say, from the centre of the scale on which the spot is at this time reflected to the mirror strikes it at right angles to a line through the centre of the latter in the plane of its suspension (see Fig. 33). (We are supposing the centre of the scale to be practically at the same height above the table as the centre of the mirror. Speaking with absolute correctness, this would not be so, as the reflection on the mirror of the light must leave its surface to fall on the scale at an angle however small). But for our purpose we may assume that the line above mentioned is at right angles to the surface of the mirror when no current is passing, and, therefore, that if the mirror were deflected either way, *this line* would strike the plane of suspension obliquely (see Fig. 33). Any considerable deflection on either side would then throw the spot off the scale. Now, in tests for C. R. it is desirable to take

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observations with both + and — currents; several of each kind are made, and the mean of these is the truest result. When taking the regular C. R. tests every day with the Wheatstone bridge this is not always done. But when operating with a submerged cable alternate currents are employed, and when testing by a reproduced deflection this object is carefully kept in view. Though we are not now concerned with the work of cable submergence, the test must be explained with as little omission as possible. The point to be aimed at is to arrange our appliances so as to have the zero in the centre of the scale, and that the deflections for either current may be within readable limits. It is evident that whatever length of cable we may have to test, if we allow the whole of the current to pass through the galvanometer coils we shall have too large a deflection; in other words, we are obliged to use a shunt, and one that will divert by far the greatest part of the current. We, therefore, introduce between the galvanometer terminals a short piece of wire, which, presenting a very small resistance, shall yet not actually short-circuit the former. We must leave it sufficient sensitiveness to show some small proportion of resistance. In Fig. 34 we have shown the connections arranged in the simplest manner for the most convenient performance of the operation. But if without further preparation a current were sent through the circuit (the cable being joined up with the galvanometer) a deflection would still not be readable, but would be off the scale. Therefore, before bringing the cable into circuit, we should join up as much resistance as will equal the estimated resistance of the former (always

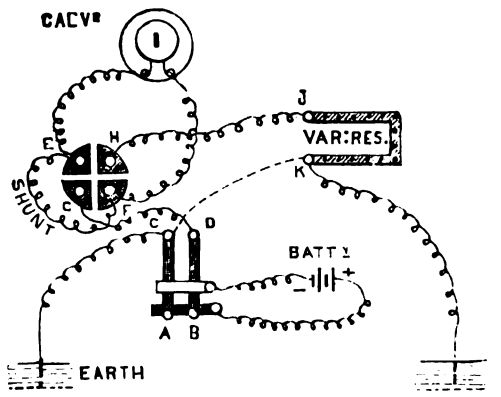

Fig. 34.

approximately known), and depressing the battery key (Fig. 34) the spot will pass off the scale; but by now turning the large directing magnet slowly round the light will be brought back to zero (at the centre), when it must be turned no further. The mirror magnet has been acted on in a direction contrary to that of the current's influence. When this point has been gained, the battery key is released, and the resistance box being disconnected, the cable is put in its place, Fig. 35. A commutator is necessary for conveniently taking this test, and we have suggested the plug arrangement as most suitable, though any reversing key would answer. Its usefulness will be at once apparent on considering that it is desirable to have the deflections for opposite currents on the same side of zero, that is, always in the same direction. We have mentioned this feature in a former number, but may allude to it at this point, as there is additional reason here for reminding the reader of the conditions governing the arrangement of the galvanometer. The thread suspending the mirror is supposed to allow of no torsion or twisting of the fibre, so that theoretically it may hang in any position, and the effect of a current in any direction is equal, or, as it may be put, an equal deflection to the right or left represents truly an equal influence in either direction on the little magnet. But it is safer to allow the opposite currents to act on the mirror in the same direction, and, when reversing the battery, to reverse also the plugs in the commutator, and read off the deflections on one side only of zero. Proceeding with the test, which we can take either with or without earth connections, according to circumstances, there is no doubt that when both ends of the cable are available it is preferable to join them up in a complete metallic circuit. Indeed, the only difficulty arising in the course of the operation is caused by what are called "earth currents," from which the cable is protected if there is no conductive communication with earth. But, as the test is more particularly employed for submerged cables when these connections are indispensable, we prefer to illustrate it in this way. The cable being joined up, we will commence by depressing the right hand key, thus sending a positive current into the circuit. We are to use alternate currents, and, although when the test is taken at the works it does not much matter which current is first applied, yet as the choice of currents to commence with is a point of some importance under other circumstances, we shall imitate it here, explaining the matter later on in its appropriate place. After removing the short-circuit plug, the effect of putting on the current is to cause a deflection on the scale which will be larger or smaller according to circumstances. It must be remembered that, since the directing magnet has been turned so as to deflect the mirror considerably from its original position at zero, when no current is passing in the circuit the spot will be invisible, that is, off the scale. It was only brought to zero after first charging through the circuit made up of the estimated resistance and the galvanometer coils. Therefore, when the cable or resistance is joined up, there is no spot visible until the battery is put on and the short-circuit plug is removed. In saying, then, that the deflection is larger or smaller, we speak of it as starting from zero, and any number of divisions for its value means counting from this point. If when the zero was

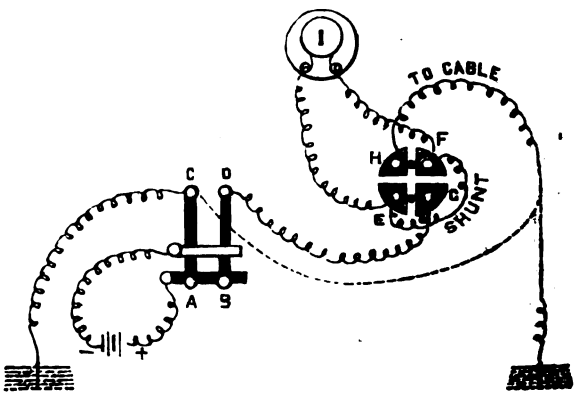

Fig. 35.

arranged the estimated resistance had been exactly equal to that of the cable, there could be no deflection at all beyond zero; but this never happens, or, at least, unless there be disturbing influences, and the resistance of the cable be varying during the test. If there be no such disturbance as arises from earth currents, and particularly if the circuit be metallic throughout (without earth connections) the deflection will be quite steady. When we go over this test at a shore station during the laying of a cable, we shall see that this is not so. Let us now suppose we have a deflection of 100 divisions, say, to the right of zero. The short circuit plug is now replaced, and the commutator and battery are both reversed. The plug between H and E will be removed to the hole between E and G, and the key B released while A is depressed, when a negative current will pass through the circuit; and on removing the plug, which is now the short circuit plug, a deflection is seen in the same direction as the first, say, 98 divisions. The positions of the key and plugs are shown in Fig. 35. By tracing the course in each case it is seen that the positive current entering through E at the terminal of the galvanometer coil has the same effect on the mirror as the negative current which passes in the opposite direction. If both had gone the same way round, the deflections would have been opposite the one to the other. The process is generally repeated several times, using alternate currents and noting the several deflections. The cable will now be disconnected, and the resistance box joined up in its place, the same amount of resistance being unplugged as before, and the deflections just given by the cable are to be repro-

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duced; or, at least, the last two of each pair if there were several taken. We commence with the negative deflection merely because the commutator plugs are in the right position (as we just now left them), and we had 98 divisions with this current. The battery key A is depressed and the short circuit plug removed; the spot should appear at zero as the original resistance is in circuit. It is required to bring it to 98 on the right hand. The question arises, Shall we unplug more resistance, so increasing the amount in circuit, or plug in so as to reduce it? This depends on the position of the plugs in the commutator when the zero was fixed by inserting the estimated resistance at the beginning of the operation, and also on the current, whether + or −, employed for that purpose. If a + current was used, and, the plugs being horizontal as in Fig. 35, if the spot was sent off scale to the right-hand, it showed that additional resistance in the circuit caused a right-hand deflection *under those circumstances*. Consequently, when with a negative current we desire to deflect the spot to 98 on the right, the plugs must not be in the horizontal position, and the resistance of the circuit must be increased. We therefore employ more resistance until we have the spot at 98. When we reverse the current, and desire to reproduce the positive deflection 100, we must still unplug more resistance, but the commutator plugs must be in the vertical position, as in Fig. 34. In the present instance there is but little resistance to be added. If we had commenced by reproducing the larger deflection, we should have to reduce the resistance when we came to reproduce the smaller value (98), and therefore to plug in the resistance-box which had too great an amount in circuit (that for 100).

If several tests with both currents have been taken, the deflections of each current are reproduced separately; that is, all the + consecutively, and the same with the −. When testing a submerged cable the resistances obtained are all more or less different. It is then customary to take a mean value for each pair of resistances of opposite currents as affording the most correct results. We shall partly explain the working out of the test at this point instead of postponing it as we have done with other tests, without, however, going exhaustively into it. Indeed, the formula once given, there is but little work to do. In this case the object is to find what is called the harmonic mean of each pair of resistances, this being the recognised C.R. of the section under test.

The learner is presumed to know that the mean of any two values or quantities in a progressive series signifies generally the average, and that, unless otherwise specified, the arithmetical mean is intended, so that, if our two resistances were 98 and 100, the arithmetical mean would be 99, or $\frac{1}{2}$ the sum of the two numbers. If there were three numbers the mean would be $\frac{1}{3}$ the sum of the three, and so on. But there is a reason for considering the true mean of two such values as these C.R.'s taken with opposite currents to be slightly different from this. We say "slightly," because the difference in question is very small for certain quantities, and in cases where the values nearly approach each other as 98 and 100. The mean called harmonic derives its name from a law governing the vibration of rods or strings under friction, and is applied in the case of electrical resistance for reasons which we cannot discuss at present. The principle is, briefly, that in comparing or taking the average value of two copper resistances taken as we have stated, that is, with alternate currents, it is not truly found as a mean or term in an arithmetical series, but as a term of a series in harmonical progression. Calculated on this ground, the mean is found by the formula stating it to be twice the product of the two resistances divided by the sum. Thus, instead of being 99 as found by the arithmetical mean we have $\frac{2 \times 98 \times 100}{98 + 100}$, which $= \frac{19{,}600}{198}$, equalling 98·98 (recurring). This difference is very small, but it could easily be seen that with resistances, differing from each other in wider proportion there could be a much greater percentage of difference between their arithmetical and harmonic means. The learner must consult his algebra for the construction of the formula if he is not familiar with the rules. At a later stage we shall consider fully the application of the theory.

THE EFFECTS OF TEMPERATURE ON THE ELECTROMOTIVE FORCE AND RESISTANCE OF BATTERIES.*a*

BY WILLIAM HENRY PREECE, F.R.S.

It is well known that heat influences the conditions of galvanic elements so as to vary the strength of the current generated by them in those parts of the circuits connecting their poles.

In 1840 De la Rive* found that the action of a galvanic pair was accelerated when it was put into hot fluid instead of cold fluid, and he attributed the result to increased chemical affinity.

Faraday† repeated De la Rive's experiment, but he, on the other hand, attributed the result to improved conductivity in the liquid, and he showed that the effect was not due either to motion, to chemical action, or to thermo-electric action, or indeed to any increase in the electromotive force.

Daniell,‡ also, found an increased current due to increased temperature. According to him one of his elements was nearly trebled in strength when raised to 212° F. He attributed the effect to the increased energy of the affinity. Said he, "Changes of temperature even have a marked influence upon the working of the voltaic battery, and must not be neglected in nice comparative experiments."

J. B. Cooke§ made careful observations on the chemical affinity in a galvanic cell, and indicated the error due to changes of temperature, but he remarked, "These affinities do not appear to be affected by any changes of temperature between the ranges of 50deg. and 212deg. F."

Crova investigated the effects of heat on the electromotive force alone, and he showed (1) that the electromotive force of a Daniell element decreases regularly with an increase of temperature; (2) that the electromotive force of a Grove element increases with temperature; (3) that the electromotive force of a single-fluid element of the Smee type is independent of the variation of temperature.

In 1862 Mr. James Dixon took advantage of the influence of heat to take out a patent for hot batteries, and he suggested the employment of these batteries for the production of the electric light.

In the same year (1862) Lindig|| indicated a variation with changes of temperature.

In 1870 Bleekrode¶ made some further experiments in the same direction.

In 1872 Mr. Latimer Clark** showed that the electromotive force of his standard cell varied inversely with temperature about ·06 per cent. for each degree Centigrade.

In 1881 Herwig†† investigated the subject carefully, and showed that polarisation diminishes with temperature. He found that resistance decreased markedly with temperature, and that this was more evident with small electromotive forces than with powerful electromotive forces.

In 1878 the author‡‡ in investigating the peculiar action of Byrne's pneumatic battery showed that its exceptional power was due to an abnormal formation of heat in its interior, and that this acted, principally, in reducing the internal resistance.

As bearing indirectly also upon this question it should be noted that Becquerel, Paalzow, and Kohlrausch and Nippoldt examined the influence of heat upon the resistance of electrolytes, and showed that it invariably diminished as the temperature rose. This was determined by them for various solutions.

Now it is to observed that in all these inquiries no one has quantitatively separated the influence of temperature upon electromotive force from its influence upon internal resistance. It is quite evident, from an examination of Ohm's law, that the variation in the strength of current can be the result either of a variation in the electromotive force alone or in a variation of the resistance alone, or in an unequal variation of both together. The numerous discrepancies that have been made in the measurements of the behaviour of the Daniell cell, as well as the erratic performance of batteries used for telegraphic purposes in various exposed positions, have long attracted the attention of the author to the necessity of a more careful inquiry into this matter than has been made hitherto. In fact, all the observations that have hitherto been made are positively useless, from the simple fact that no record has been kept of the independent variations of the internal resistance and the electromotive force in any measurable or comparable manner.

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a Abstract from a paper read before the Royal Society.

* *Ann. Chem.*, 1828, xxxvii, p. 242. † *Researches*, 17th series, §§1925-26.

‡ *Chemical Philosophy*, p. 506. § *Phil Mag.*, 1861, p. 95.

|| *Phil. Mag.*, 1865, I., p. 408. ¶ *Phil. Mag.*, 1870, p. 310.

** *Phil. Trans.*, 1873. †† *Ann. Phys.*, B. XI., H. 4, No. 12. p. 661.

‡‡ *Proc. Soc. Telegraph Engineers*, 1878.

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Special apparatus was made, and the following method of experimenting was decided upon.

The cell to be experimented upon was placed inside a cylindrical copper vessel about 10 inches high and about 8 inches diameter; water was poured into the vessel to within an inch of the top of the cell, and the lid of the vessel was put on.

This lid had four holes, two (insulated from the rest of the vessel) to receive the electrodes of the cell, and the other two to allow thermometers to be plunged into the liquid or liquids in the cell without removing the cover or lid. The water in the vessel and the cell in the water were then heated by means of a gas-burner placed underneath the vessel, and the electromotive force and the resistance of the cell were determined at various stages of the heating; while the temperature of the cell was observed at the time of each experiment, the liquid or liquids in the cell were stirred up from time to time, so as to obtain, as far as possible, the true temperature of the cell.

The cells experimented upon were the Daniell, bichromate, and Leclanché; those in general use, especially for telegraph purposes.

The results of the experiments are given in the tables below, in which the electromotive force (e) is given in terms of that of a Daniell cell (a standard cell) in good order and at about 14deg. C., and the resistance is given in B.A. units. The experiments were conducted for me by Mr. R. Shida with great care and patience. Of the Tables I., II., and III., which contain the results of the experiments on the Daniell cell, the first two tables refer to the case where the solution of copper sulphate was saturated at all temperatures (that is to say, the crystals of copper sulphate were always present in the solution) and the solution of zinc sulphate was kept the same, or nearly the same, in strength (that is, the solution was saturated at about 14deg. C.). Table III. refers to the case where both copper sulphate and zinc sulphate solutions were kept unaltered or nearly so in strength during the experiment (that is to say, they were both saturated at about 10deg. C.). Table IV. contains the results

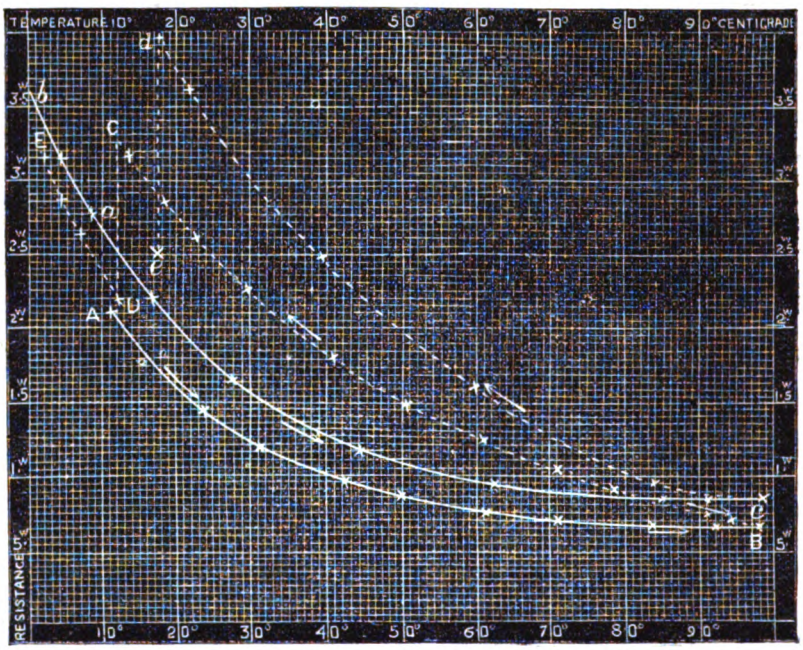
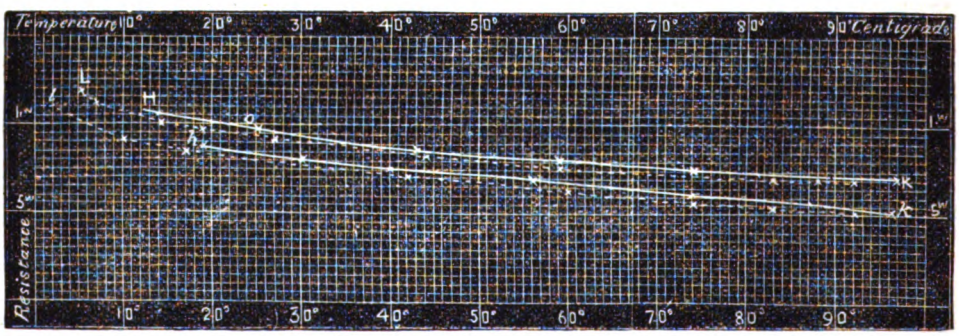


DIAGRAM I.



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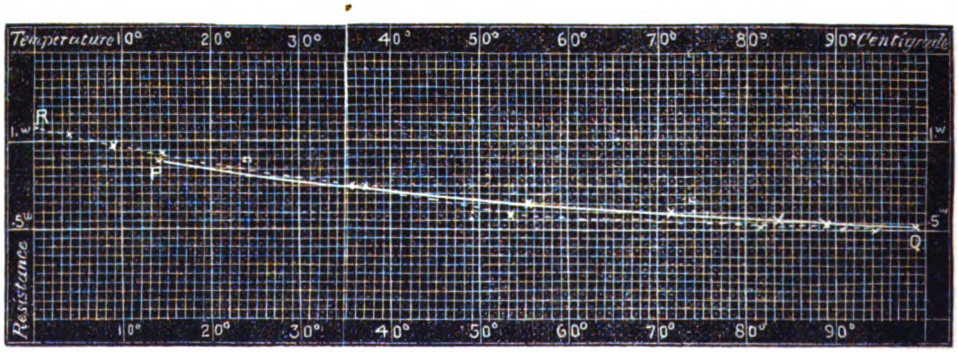

DIAGRAM III.

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for the double-fluid bichromate; Table V. those for the single-fluid bichromate; and Table VI. those for the Leclanché.

(1.) As regards the electromotive force. *(a.) The Daniell Cell.* Tables I., II., and III. show that, as the cell was heated up from a comparatively low temperature to a higher and higher temperature, the electromotive force of the Daniell cell decreased rather abruptly at first, but more gradually afterwards, until, at a certain temperature it began to increase and continued to do so till the temperature attained that of the boiling point of water; but that (which is rather singular) the electromotive force remained unaltered, or nearly so, while the cell was being cooled down from 100deg. C. to a lower and lower temperature. These peculiar results (together with the fact that whereas the temperature of the zinc cell rose faster than that of the copper cell while being heated up, the former cooled faster than the latter while cooling down from a high temperature—say 100deg.C.) tend to indicate that the diminution in the electromotive force of the cell at the beginning of the experiment was greatly, if not chiefly, due to the thermo-electric action which must have been set up in the circuit.

(b.) The Bichromate Cell.—It will be seen from the Tables IV. and V. that the electromotive force of the bichromate (both the double-fluid and the single-fluid cell) diminished regularly when the temperature was made higher and higher, and increased regularly when the temperature was made lower and lower. The regular diminution by rise and regular augmentation by fall of temperature of the electromotive force (at least when the range of temperature was between 0deg. C. and 100deg. C.), was very much greater in the case of the single-fluid bichromate than in the case of the double-fluid bichromate. In the case of the first, the electromotive force at 100deg. C. was as much as about 6 per cent. lower than that at about 14deg. C.; whereas, in the case of the second the electromotive force at 100deg. C. was only about 1·6 per cent. lower than at 19deg. C.

(c.) The Table VI. shows that the electromotive force of the Leclanché varied when the temperature was varied so slightly, if at all, that it was difficult to observe the variation by the method used.

(2.) *The Internal Resistance.*—The results obtained for the resistances of the various kinds of cells are more striking and more interesting than those for the electromotive force, as will be quite evident from the tables. They will, however, be understood more readily from the graphical representations of the results by means of curves (in the Diagrams I., II., and III.), in which the abscissæ are proportional to the resistances in B.A. units, and the ordinates to the temperatures in degrees Centigrade.

(a.) The Daniell Cell.—The curves in the diagram I represent the results for the Daniell, the curve ABCDE corresponding to the case (Table II.) in which the copper sulphate solution was kept saturated at all temperatures, while the zinc sulphate solution was kept constant in strength, and the curve *abcde* corresponding to the case (Table III.) in which both solutions were kept unaltered in strength during the experiments. The directions of the arrows indicated the order of the experiments. For instance, in the curve ABCDE the portion AB represents the result obtained while the cell was being heated up from about 11deg. to C. nearly the boiling point of water, the portion BC that obtained while the cell thus heated up was being cooled down from 100deg. C. to about 12deg. C.; and, lastly, the portion DE that obtained in cooling the cell from 12deg. C. to nearly so low a temperature as the freezing point of water. A very similar explanation applies to the curve *abcde*.

The results thus laid down by means of the curves ABCDE and *abcde* present many points of interest. These curves clearly show:—

1°. That when a Daniell cell is heated from a low temperature, say 0deg. C., up to a high temperature, say 100deg. C., the resistance of the cell decreases rather abruptly at first, but more gradually afterwards, falling from 2·12 to ·66 ohms, or more than one-third.

2°. That when the cell thus heated up is cooled down, the resistance increases, but increases in a greater rate than it decreased while being heated; in other words, the resistance of a Daniell cell at any temperature (at least between 0deg. C. and 100deg. C.) is smaller before it is heated up to a high temperature than afterwards, provided the heating and cooling be done not very slowly.

3°. That if the cell thus cooled down be left undisturbed at a certain temperature, the resistance of the cell gets less and less, till at last, at the end of a certain period (which will be from about 40 to 50 hours), it gets down to the value which it had before being heated up at all.

4°. And, lastly, that the resistance of a Daniell cell is considerably less when the solution of the copper sulphate is more concentrated than when it is less concentrated, at any temperature, and under otherwise exactly similar circumstances.

TABLE I.

Daniel cell.—Zinc sulphate solution saturated at about 14° C., and copper sulphate solution saturated at all temperatures.

Time.		Temperature.			D.	*d*.	*d'*	*r*.	*e*.	*b*.
Date.	Hour.	Copper sulphate solution.	Mean.	Zinc sulphate solution.						
Dec.	A.M.									
9	11	13° C.	13°C.	13° C.	288	288	119	3	1·000	2·12*
		26	23	20	,,	285	94	,,	·990	1·48
		40	33	26	,,	285	81	,,	·990	1·19
		52	43·5	35	,,	285	70	,,	·990	·98
		64	56·5	49	,,	285·5	61	,,	·991	·82
		78	71·5	65	,,	286·5	56	,,	·995	·73
		84	79·5	75	,,	286·5	54	,,	·995	·70
		86	83	80	,,	286·5	53	,,	·995	·68
		89	86	83	,,	286·5	53	,,	·995	·68
		98	95·5	93	,,	287	52	,,	·996	·66
		100	100	100	,,	287	52	,,	·997	·66†
		95	95·5	96	,,	288	58	,,	1·000	·76
		90	90·5	91	,,	288	62	,,	1·000	·82
		80	81·5	83	,,	288	68	,,	1·000	·93
		70	70·5	71	,,	288	76	,,	1·000	1·08‡
		60	60	60	,,	288	88	,,	1·000	1·32
		47	47	47	,,	288	104	,,	1·000	1·70
	P.M.	35	35	35	,,	288	122	,,	1·000	2·20
9	7	25	25	25	,,	288	134	,,	1·000	2·61§
	A.M.									
11	10:30	11	11	11	283	288	122	,,	1·000	2·18

* Heating commenced. † Heating stopped. ‡ Hot water removed and cold water poured in the vessel. § Experiments stopped and everything left undisturbed till the morning of the 11th.

N.B.—If E and *e* be the electromotive force of the standard cell and the cell examined respectively, and *b* the resistance of the latter cell, then

$$e = \mathrm{E} \times \frac{d}{\mathrm{D}}, \qquad b = r \times \frac{d'}{d - d'}.$$

TABLE II.

Daniell Cell.—Zinc sulphate solution saturated at 14° C., and copper sulphate solution kept saturated at all temperatures.

Time.		Temperature.			D.	*d*.	*d'*.	*r*.	*e*.	*b*.
Date.	Hour.	Copper sulphate solution.	Mean.	Zinc sulphate solution.						
Dec.	A.M.									
11	10:30	11°C.	11°C.	11°C.	288	288	122	3	1·000	2·18*
		25	22	19	,,	285	94	,,	·989	1·48
		36	31	26	,,	284·5	82	,,	·988	1·21
		48	42	36	,,	285	72	,,	·989	1·01
		56	50	44	,,	285·5	66	,,	·991	·92
		68	61·5	55	,,	286	59	,,	·993	·78
		78	71·5	65	,,	287	54	,,	·996	·70
		89	84	80	,,	287	53	,,	·996	·68
		96	93·5	91	,,	288	52	,,	1·000	·66
		99	98	97	,,	288	52	,,	1·000	·66†
		95	95·5	96	289	289	54	,,	1·000	·68
		91	92	93	,,	289	58	,,	1·000	·75
		82	83	84	,,	289	66	,,	1·000	·89
		71	72	73	,,	289	73	,,	1·000	1·01
		59	61	63	,,	289	84	,,	1·000	1·23
		50	50·5	51	,,	289	95	,,	1·000	1·47
		41·5	42	42·5	,,	289	106	,,	1·000	1·74
		30	30·5	31	,,	289	124	,,	1·000	2·25
		21	22	23	,,	289	134	,,	1·000	2·60
	P.M.	17	18	19	,,	289	141	,,	1·000	2·86
11	7:15	13	13	13	,,	289	149	,,	1·000	3·19‡
	A.M.									
12	11:40	12	12	12	,,	289	123	,,	1·000	2·22§
		6	7	8	,,	289	136	,,	1·000	2·66
	P.M.	3	4	5	,,	288	142	,,	·996	2·90
12	1:0	2	2	2	,,	288	146	,,	·996	3·06

* Heating commenced. † Heating stopped, lid of vessel taken off, hot water removed and cold water poured in. ‡ Experiment stopped and everything left undisturbed till next morning. § Cooling by means of ice commenced.

(b.) The Bichromate Cell.—The results for the bichromate are not quite so remarkable, nor are they so interesting as those for the Daniell cell, as will be seen on comparing the curves in the Diagram I. with those in the Diagram II.; but the fall of resistance is, nevertheless, very striking. In the case of the double-fluid bichromate, the curve HK of resistance obtained while the cell was being heated up, differs so slightly from the curve KN obtained while it was being cooled down, that the one is hardly distinguishable from the other. The differences in fact may be attributed more to errors of observation than to anything else. Yet, if there should be any difference in the resistance in

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the two cases, it is one opposite in character to that found in the case of the Daniell cell.

The probability of the existence of this difference, as indicated by the curve HKL, is supported by the results shown by means of the curve *hlk* for the single-fluid bichromate cell. Every point of the portion *hk* of the curve obtained while heating the cell up, lies considerably higher than the corresponding point in the portion *kl* obtained while cooling it down; that is to say, the resistance of the single-fluid bichromate cell at any temperature is greater before than after it has been heated up.

(*c.*) Very little remains to be said of the curve PQR in the Diagram III., which represents the results for the Leclanché cell. The general character of the curve PQR bears a strong resemblance to the curve HKL; in other words, the resistance of the Leclanché diminishes with the rise, and increases with the fall of temperature in nearly the same rate as the resistance of the double-fluid bichromate cell does. And, morever, it is a matter of difficuly to say with certainty, in the case of the Leclanché as in the case of the double-fluid bichromate, whether or not the curve of resistance obtained while being heated up coincides with the curve of resistance obtained while being cooled down, because the part RQ is so nearly coincident with the part PQ of the curve PQR, that any slight errors in the observations may have caused the non-coincidence between the two parts.

TABLE III.

Daniel Cell.—Both zinc sulphate and copper sulphate solution very nearly saturated at about 10°C.

Time.		Temperature.			D.	*d.*	*d'.*	*r.*	*e.*	*b.*
Date.	Hour.	Copper sulphate solution.	Mean.	Zinc sulphate solution.						
Dec.	P.M.									
19.	1:0	7°C.	9°C.	11°C.	227	227	108	3	1·000	2·72*
		3	4	5	,,	227	117	,,	1·000	3·19
	3:15	0	0	0	,,	227	123	,,	1·000	3·55†
	A.M.				232	232	98	,,	1·000	2·19
20.	10:20	17	17	17	232	232	98	,,	1·000	2·19‡
		34	28	22	,,	230	80	,,	·991	1·60
		52	45	38	,,	229	63	,,	·987	1·14
		70	63	56	,,	229	54	,,	·987	·93
		84	79	74	,,	230	53	,,	·991	·90
	P.M.	93	91	89	,,	230	52	,,	·991	·88
	2:0	99	98	97	,,	230	52	,,	·991	·88§
		86	84	82	,,	231	56	,,	·996	·96
		55	60	65	,,	232	82	,,	1·000	1·64
		35	39	43	,,	332	104	,,	1·000	2·44
		20	21	22	,,	232	126	,,	1·000	3·57
	6:40	17	17	17	,,	232	130	,,	1·000	3·87‖
	A.M.									
21.	11:0	17	17	17	232	232	106	,,	1·000	2·52

* Cooling by ice and salt commenced. † Experiment stopped. ‡ Commenced heating. § Stopped heating. ‖ Experiments stopped and everything left undisturbed till next day.

TABLE IV.

Double-fluid Bichromate Cell.

Time.		Temperature.			D.	*d.*	*d'.*	*r.*	*e.*	*b.*
Date.	Hour.	Carbon cell.	Mean.	Zinc cell.						
	A.M.									
Dec. 14.	11:10	14°C.	14°C.	14°C.	222	429	219	1	1·932	1·04*
		23	25	27	,,	446	208	,,	1·919	·95
		48	43	38	,,	425	195	,,	1·914	·85
		62	59	56	,,	424	188	,,	1·910	·80
		79	74	69	,,	423	180	,,	1·905	·74
		84	81	78	,,	423	177	,,	1·905	·72
		92	88	86	,,	423	172	,,	1·905	·69
		98	97	96	,,	423	168	,,	1·905	·66†
		84	83	82	,,	423	174	,,	1·905	·70
		52	59	66	,,	425	182	,,	1·914	·75
		41	45	47	,,	426	194	,,	1·919	·84
	P.M.	25	27	29	,,	428	208	,,	1·928	·95‡
Dec. 14.	5:15	17	17	17	,,	429	217	,,	1·932	1·02
Dec. 16.	10:20	14	14	14	,,	429	219	,,	1·932	1·04
		6	7	8	,,	429	229	,,	1·932	1·14§
		4	4·5	5	,,	429	234	,,	1·932	1·20
Dec. 16.	2	2·5	3	3·5	,,	429	237	,,	1·932	1·23

* Heating commenced. † Heating stopped. ‡ Experiments stopped and everthing left undisturbed till December 16th. Process of cooling by ice commenced.

It follows from these experiments that changes of temperature do not practically affect electromotive forces, but that they materially affect the internal resistances of cells. Faraday's observation is fully confirmed, while Daniell's mistake is easily understood if he employed, as he probably did, a galvanometer of low resistance.

It also follows that of the various forms of batteries in practical use the Daniell is most seriously influenced by variations in temperature, and that in all experiments with that battery either the temperature must be kept constant or frequent measurements should be taken of its internal resistance, and allowance made for the variation.

TABLE V.

Single-fluid Bichromate Cell.

Time.		Temperature of the cell.	D.	*d.*	*d'.*	*r.*	*e.*	*b.*
Date.	Hour.							
Dec. 28.	10:50 A.M.	19° C.	212	408	190	1	1·924	·87*
		29	,,	405	182	,,	1·910	·81
		40	,,	404	177	,,	1·906	·75
		56	,,	403	167	,,	1·901	·71
		74	,,	398	156	,,	1·878	·66
		87	,,	392	140	,,	1·849	·56
		92	,,	386	131	,,	1·820	·51
		96	,,	384	128	,,	1·810	·50†
		83	,,	388	135	,,	1·830	·53
		74	,,	392	140	,,	1·849	·56
		60	,,	397	152	,,	1·872	·62
		42	,,	404	169	,,	1·906	·72
		17	,,	408	184	,,	1·924	·82‡
		10	,,	408	196	,,	1·924	·92
		2	,,	408	222	,,	1·924	1·11

* Heating commenced. † Heating stopped. ‡ Cooling by ice commence d

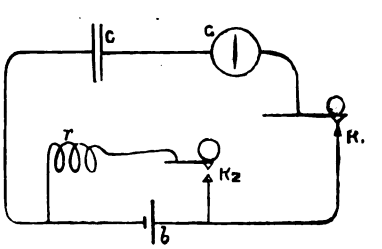
TABLE VI.

Leclanché Cell.

Time.		Temperature.			D.	*d.*	*d'.*	*r.*	*e.*	*b.*
Date.	Hour.	Zinc cell.	Mean.	Carbon cell.						
	A.M.									
Dec. 18.	10:45	14°C.	14°C.	14°C.	227	312	146	1	1·375	·87
		22	20	18	,,	312	142	,,	1·375	·84*
		40	36	32	,,	312	134	,,	1·375	·75
		60	57	54	,,	312	120	,,	1·375	·63
		76	73	70	,,	312	116	,,	1·375	·59
		87	84·5	82	,,	312	112	,,	1·375	·56
		92	89	86	,,	312	110	,,	1·375	·54
		94	91	88	,,	312	108	,,	1·375	·53
		97	95	93	,,	312	106	,,	1·375	·51†
		80	83	86	,,	314	110	,,	1·383	·54
		52	56	60	,,	313	124	,,	1·379	·66
	P.M.	34	35	36	,,	312	136	,,	1·375	·77
Dec. 18.	6:15	20	21	22	,,	312	145	,,	1·375	·87‡
	A.M.									
Dec. 19.	11	15	15	15	,,	312	148	,,	1·375	·90
		8	9	10	,,	313	154	,,	1·379	·97§
		3	4	5	,,	312	158	,,	1·375	1·03
		0	0	0	,,	312	164	,,	1·375	1·10

* Heating commenced. † Heating stopped. ‡ Stopped observations, and everything left undisturbed till next day. § Process of cooling by ice and salt commenced.

The method adopted to measure the electromotive force and the resistance of the different cells was very simple, and as it is believed to be very accurate and free from any of the disturbing



influences due to polarisation, a description of it may be useful. The charge or discharge of a small condenser through a galvanometer of comparatively low resistance is an accurate measure of the electromotive force present, for the duration of the current is extremely short, and, therefore, the whole quantity present acts as a balista upon the needle. C is a condenser of ·3 microfarad capacity, G a sensitive reflecting galvanometer, *b* the cell to be measured, *r* a shunt of small resistance, and K, and K_2 simple keys. The condenser is first charged with

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a standard Daniell cell, and the charge deflection (D) noted. The standard cell is then replaced by the cell b to be examined, and the charge deflection (d) produced by it noted. The key K_2 is then depressed while K_1 is held down, and the cell is thus shunted through r. The electromotive force affecting the condenser is thus reduced, and a discharge (d') is noted—the deflection being in the reverse direction to d. Now, if E and e are the E.M.F.'s of the standard cell and cell b respectively, and b be the resistance of the cell under test, then

$$b = r\frac{d'}{d - d'}.$$

This particular mode of measuring was devised by Mr. H. R. Kempe, and modified by Mr. Munro, but condensers are much used in telegraphy for measuring electromotive forces.

ELECTRIC LIGHTING.

The Board of Trade has issued draft clauses such as are intended to be inserted in Provisional Orders, and with the draft clauses is the following memorandum :—

The following clauses are submitted for consideration as rough drafts of model clauses which are proposed to be inserted in Provisional Orders, and, so far as applicable, in licenses granted under the Electric Lighting Act, subject to such modifications as local circumstances may in any case render expedient.

They do not, of course, constitute a complete Order. Clauses applicable only in particular cases, clauses with regard to the breaking up of private streets, railways, tramways, &c., general clauses as to notices, &c., saving clauses, and others are omitted, but they are intended to include the main subjects of general interest as to which any controversy is likely to arise.

The following points require special attention :—

1. *The Choice of the Area of Supply.*

The clauses with regard to this are framed on the supposition that a fair area should be included in Schedule A, in which the undertakers may make an experiment, and to which, if they find that experiment not sufficiently remunerative to induce them to extend their operations, they may be allowed to confine themselves. At the same time, it is proposed that a further area should be included in Schedule B, to which the undertakers may, after feeling their way by their first experiment, extend their operations by degrees, subject to the right of the local authority, or where the local authority are themselves the undertakers, of certain inhabitants, at any time to require the undertakers to forthwith extend their operations over any part of such area or to resign their rights over such part. It is, therefore, suggested that local authorities in whose districts companies are seeking powers would do well to take care that the area proposed to be included in Schedules A and B respectively, are such as may fairly be included therein, having regard to the future development of the supply of electricity within the district. If, owing to local circumstances, as, for instance, in the case of small towns, they deem it necessary to allow the undertakers to include in Schedule A all the most remunerative part of the district, it will be for them to consider whether they should not propose clauses for withdrawing some part of the area included in Schedule A from the area of supply if the undertakers decline to extend their operations beyond it in order to encourage other undertakers to come in and supply a larger area.

2. *The Question of Capital.*

The clauses on this subject are only applicable in the case of companies. In such a case it is proposed that the undertakers should be required within six months to set aside and appropriate as a separate capital, for the purposes of the particular undertaking, such a sum as would appear reasonably sufficient to enable them to meet all probable demand for a supply in the area included in Schedule A; and, in addition to this, and as a part of such separate capital, to deposit or secure to the satisfaction of the Board of Trade within the same period a sum not less than one-half the amount, which may be reasonably calculated as the capital necessary to enable them to execute the works which they are required to execute within two years in certain specified streets in Schedule A., and to supply electricity therein. Similarly, in the case of Schedule B., additional sums are from time to time to be added to the separate capital of the undertaking, and fresh sums to be deposited or secured in respect thereof as separate parts of the area included in Schedule B are added to the area of supply to such amounts respectively as the Board of Trade upon directing such additions to be made may prescribe.

3. *As to the Modes of Supply.*

The parallel system is the system of supply adopted as the standard system in these clauses, and it is not proposed at first to give a right either to the local authority or to private consumers to demand a supply for public or private lighting on any other system; the provision is made that with the approval of the Board of Trade any other system may be substituted. Of course, by agreement any system whatever may be employed, provided that it complies with the regulations as to safety and otherwise, special provision being made in the clauses that if it is desired to supply at high tension for arc lighting or other purposes this may be done under special regulations.

4. *As to Time of Supply.*

It is proposed that this should be continuous, subject to six months' grace upon first commencing supply, when the undertakers need only supply between sunset and sunrise, and to a power on the part of the Board of Trade to permit special intermissions for the purposes of testing or otherwise. It may, however, be well for local authorities to consider in every case how far continuous supply is desirable for their district; as, however necessary it may be thought in crowded cities, where artificial light may probably be in constant demand, where there is only a slight demand in the daytime, as in country towns, the small additional convenience may not improbably be more than counterbalanced by the much higher price which must almost of necessity be charged for electricity where there is a continuous instead of an intermittent supply.

5. *As to Price.*

It is proposed that electricity should in all cases be charged for by meter; but as at present it seems doubtful whether there is any reliable meter for quantity or energy, a power is given to the undertakers to charge for the present, and until the Board of Trade otherwise direct, by the maximum current required, and the number of hours during which electricity is used. The latter, however, does not seem a very satisfactory mode of charging, and it is hoped it may soon be dispensed with, as there seems to be no doubt that meters for quantity and energy will soon be perfected for practical use.

6. *As to Limitation of Profits, Revision of Prices, Monopoly, &c.*

No clauses are inserted dealing with the above subjects. In the case of companies the undertaking can be purchased by the local authority at farthest at the end of twenty-one years at the then value of the plant. In the meantime there is, in the first place, the competition with gas, which is likely to be very severe; and, in the second place, the potential competition with other undertakers to keep down prices, as the Board of Trade see no reason whatever why such last-mentioned competition should not be an active and potent force. The accounts of the undertakers are open to all. No monopoly is, under the Act or the Provisional Order, granted or intended to be granted to them; and should they neglect their duties in the district, or charge exorbitant prices, there is nothing to prevent the immediate grant of a license or Provisional Order to a competing set of undertakers within the same district. In the case of local authorities there will be not only competition to look to, but also public opinion, and the Board of Trade prefer to rely upon the above considerations rather than to attempt to impose artificial restrictions, which, in other cases, have not proved too successful.

N.B.—*Any person desirous of offering any criticisms or suggestions with regard to these clauses is requested to do so by letter, addressed to the Board of Trade, and marked on the outside of the cover enclosing it "Electric Lighting Act," on or before the 14th day of March next.*

Board of Trade, T. H. FARRER.
26th February, 1883.

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J. G. Blackburn.—We do not know the address of Mr. St. George, the inventor of the telephone you mention.

R. Bowman.—We do not know of such apparatus. Send drawing as suggested.

D.—Would like to know of a dynamo, giving about 17 amperes with 160 volts E.M.F. Can any correspondent give the required information?

R. C. Shettle.—You had better apply to the Electrical Power Storage Company, Great Winchester-street, E.C.

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THE MEASUREMENT OF ELECTRICITY FOR COMMERCIAL PURPOSES.

The paper of Mr. Shoolbred read at the last meeting of the Society of Telegraph Engineers is an interesting *resumé* of existing information relating to special forms of apparatus for certain electrical measurements. The present is a kind of transition period, so far as the measurement of electrical quantities is concerned. In the application of electricity to telegraphy the quantities to be measured have been wondrously small, and the majority of existing instruments were designed with a view to the measurement of these small quantites. The introduction of the electric light upon a practical scale involved its establishment upon broad, but in many respects well defined commercial principles. The introduction of electrical transmission of power involves commercial principles similar to those applicable to the electric light. In telegraphic matters the producer and the user of electricity is generally one and the same person, but the same does not hold in the case of the general introduction of the electric light, nor will it hold in the electrical transmission of power. The producer and the user will be different persons, and hence the user will require some means of ascertaining the quantities he uses. A suggestion has been recently made that householders should be charged for light somewhat on the same principle as they are charged for water—by the size and rent of the house. We do not, however, consider such a system practicable. It is well known that in the case of water many users prefer to be charged by measurement and not by rule of thumb. We shall not discuss this suggestion further, but assume at once that in some shape or other the supply of electricity must be measured. The general public ask, Can such measurements be made? The scientific world answer they can, and already several inventors have devised apparatus for such work. The general tendency is to devise some apparatus that will do for electricity what the meter does for gas, and an automatic register will show the consumer the exact state of affairs from day to day. A knowledge of the laws which govern electricity is known to a comparatively small number of engineers, and those outside the select circle are somewhat incredulous as to what can be done. The President of the Society of Engineers, in his recent inaugural address, hinted at the doubts which are abroad. He said:—"Of course there are meters which register the current passing at any moment; but when it comes to the question of registering the amount of electricity which has passed through a wire during a given period, it is questionable whether it can be done in a reliable manner, inasmuch as the electrical energy is partially exhausted in the process of registration." We confess this sentence has led us to touch upon the subject now, for Mr. Shoolbred's paper clearly explains itself. It gives definitions and it describes apparatus, but we fear does not enlighten men who hold similar views to those just quoted. It is not proposed to send the working current of electricity through the meter, and, therefore, its electrical energy will not be partially exhausted. At present most of the proposed methods of measurement bear some analogy to the measurement of water passing through a large pipe by means of measurements taken of water passing, under similar conditions of head, &c., through a much smaller pipe. For example, suppose we have a mass of water, the head of water being constant. The water to perform work is taken through a pipe of area x, while the water actually measured in gallons or tons passes through a parallel pipe of area $\frac{1}{1,000}x$, or $\frac{1}{10,000}x$. Surely we can get an approximately correct idea of the quantity passing through the larger pipe in a given time. The electrical case is, however, simpler than that of the water. A definite but comparatively small portion of the total current will be taken through a branch wire, and this small quantity measured

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just as if $\frac{1}{10,000}$th part of the gas was used to actuate a measuring instrument. So long as the proportion 1 to 10,000 was absolutely correct, so long would the user be able to tell at a glance at his register the quantity used, and we think we may safely state that the science of electricity is sufficiently advanced to enable us to give exactly the proportion of current used to actuate the register to that used in the working circuit. A definite quantity of electricity will perform a definite amount of work, and inventors like Sprague and Edison, knowing this fact, propose to use a certain proportion of the total current in doing such work as depositing a metal electrolytically. If a meter constructed upon this principle is placed in a house in connection with the electric light, $\frac{1}{10,000}$th, say, of the current coming to the house is used in the register, the other 9,999 parts are used by the householder. Hypercriticism from lovers of gas says some one has to pay for the quantity so used. This is admitted, with the addition that the quantity lost in this way will be so small as to have no appreciable effect upon the price. The proportion lost may be only one in a million, and we are quite sure one foot of gas lost in one million consumed would make no difference to the cost of gas. We have attempted to throw a little light upon this subject for the benefit of those who are not electricians, but who are taking considerable interest in the recent developments of electricity.

CORRESPONDENCE.

THE INVENTOR OF THE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is impossible to let your article on the telephone appeal case pass without comment, and inasmuch as at least one of those who might protest is passed beyond the grave I venture to speak in his behalf.

The writer of the article says:—"It is by no means certain that the other investigators (including Reis) were even aiming at the result he (Graham Bell) aimed at—telegraphic signalling being far away different from vocal signalling." On the contrary, it is absolutely certain not only that Reis aimed at vocal signalling, but that he did not aim at multiple acoustic telegraphy. Reis himself in 1861 (*vide Journal* of the Physical Society of Frankfort, where Reis's paper "On Telephony by the Galvanic Current" appears in full) constructed his instrument—a combination of a tympanum with an electric current regulator—for the purpose of transmitting all tones that a human ear can hear, and chose the human ear with its tympanum as his model, *because* the human ear is, as he tells us, the organ which can take in the resultant effect of all the complicated vibrations produced by the organs of *speech*. That he aimed directly at this result is absolutely clear. That he attained at that time to a certain degree of success is equally clear, for he discusses the reasons why he did not get all the vowel sounds with equal distinctness. A year later, with perfect instruments, still based on the type of the human ear, he succeeded in transmitting speech so well that the varied inflexions of the voice in surprise, interrogation, command, &c., could be recognised. He himself gave to his instrument the name of "The Telephone," a name which the later patentees of improvements have still retained. Far be it from me to discredit the merit of their improvements; but since both Graham Bell and Edison have in their own published writings recognised the claims of Reis by quoting the very documents in which Reis's claim to invent "The Telephone" had been set forth in 1861-2, and in which that which I have stated above about the intent and extent of the invention is to be found, I, who go back to the documents to which both Bell and Edison refer me, and find there Reis's own invention set forth and claimed as his, am bound to accept the reference, and to believe that Reis did invent what he says he intended to invent, namely, an instrument which should transmit to a distance, by the agency of an electric current, "the total actions of *all the organs operating in human speech*."

What are the facts? A man in 1861-2 invents an instrument and tells you what it is for. He tells you you have to talk or sing into one end of it, and that speech or song, as the case may be, will be transmitted to the other end. We try it, and we find that we can make it work and speak uncommonly well. Surely this is the very essence of invention, and yet, in 1883, the writer of an article in *The Electrician* can be found who will say that it is by no means certain that Reis "was even aiming at the result" which Graham Bell aimed at!

The writer of this same article—the accuracy of which may be pretty well judged of by the foregoing sample—proceeds to say that Reis's instrument "in the hands of experts can now be made to speak *like a telephone*, or, at all events, some people are obliging enough to fancy that it can." This is magnificent. We shall, perhaps, be told next that a Duboscq lamp can in the hands of experts be made to shine like an electric light, or that, at all events, some people are obliging enough to fancy that it can. But the writer has surpassed himself when he proceeds:—"In the hands of Reis it could not articulate, and on the principle of construction adopted by him it never would have articulated, except by accident." Very cleverly put, perhaps, but, unfortunately, untrue. But mark what follows:—"That accident did not occur, or, *if it did*, it threw no light on the cause of its occurrence!" Let us proceed with our paraphrase, and see how it would look if we were to be told "In the hands of Duboscq the lamp would not give light, and on the principle of construction adopted by him it never could have emitted light except by accident. That accident did not occur, or, if it did, it threw no light on the cause of its occurrence or on the true conditions of success in electric lighting." Yet there is just as much evidence that Reis intended his telephone to transmit speech as that Duboscq intended his lamp to emit electric light. Neither was perfect. But each attained its own measure of success, and each was a meritorious invention.

One word more on the principle of construction—it was twofold. In the transmitter the essential feature was the combination of a tympanum (to imitate that of the ear), with a certain electric mechanism, whose function is to control the current by interrupting it in proportion to the degree of condensation or rarefaction of the impressed sound-wave. That fundamental principle is to be found in every transmitter used in every existing telephone exchange in Great Britain to-day. In the receiver he had two alternative principles, one of which survives in the modified instrument of Graham Bell, namely, that of employing an electro-magnet—a coil of wire wound round a core of magnetic metal—to translate the electrical vibrations of the current into mechanical vibrations in an armature of iron. Reis used as armature an iron bar—the more modern instruments have an iron plate, but the principle of action is identical. All that is really essential in the transmitter, and all that is really essential in the receiver—the varying degree of interruption imposed by the voice on the current at one end and the varying degree of attraction imposed by the electro-magnet on the armature at the other—is to be found in Reis's invention; all the rest is not essential, and may be varied in thousands of ways. The injustice of denying him the credit of his invention is the more flagrant since he is no longer living. To rob the living of the fruits of their own thought and genius is a crime; to rob the dead is a criminality doubly detestable. All honour to Bell and to Edison for the brief recognition they have each personally given to the labours of Philipp Reis. But for those who, for pecuniary or other ends, despoil the dead, and in the face of evidence of contemporary witness and contemporary works deny that the deceased inventor ever intended the telephone

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which he invented to do that for which he designed it, for these, I say, no condemnation is too strong.

Lastly, I observe from public advertisements that Sir F. J. Bramwell, F.R.S., is to lecture on telephones before the Institution of Civil Engineers on March 1. As Sir Frederick is always on the side of the angels, I shall be curious to hear what he will have to say concerning the inventor of the telephone.—Yours, &c., SILVANUS P. THOMPSON.

Bristol,
Sunday, Feb. 25, 1883.

[We gladly insert Professor Thompson's letter, especially as he would seem to be in possession of information which has not yet been made public. So far as the evidence here adduced by him tends to modify any statement in our leading article we accept the correction, not only with a good grace, but with extreme pleasure, taking leave, however, to put our own estimate on the nature and value of the correction. We never denied that Reis "attained a certain degree of success;" the question is what was the *kind* of success aimed at and attained? And this question, we take leave to point out to Professor Thompson, is not affected in the least degree by whether Philipp Reis is dead or alive. If our esteemed correspondent seriously believes there are people who would "despoil the dead" [Reis] "for pecuniary or other ends" the best thing he can do is to let the world know all about Reis's invention. We shall be happy to assist him in giving it publicity, even at the risk of being accused of despoiling the living—by people who disagree with Professor Thompson.—ED. *E.*]

AN ARC LAMP TO BURN AT ANY ANGLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should be very much obliged to you or any of your subscribers who could inform me if there is yet invented an arc lamp that will burn in any other position than vertically. It must have no clockwork, &c., near the centre of light, and, therefore, the carbons and their holders must be long, and the lamp must be capable of being used with very powerful currents. No lamp where the upper carbon falls by gravity or the length of the arc regulated by weights would answer the purpose.—Yours, &c., INQUIRER.

NEW TELEPHONE SWITCH BELL.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Knowing that you advocate "honour to whom honour is due" in your columns, in the name of fair play I desire to state a few facts. There are about a thousand subscribers in connection with the Manchester Telephonic Exchange. All of these are provided with two press buttons on their instruments—an ordinary (white) one in the switch bell, and a "commutator" (black) one contained in a separate box wood case. They "call" the central with either, but when "through" they only use the white one to ring each other. When finished talking, they press the black button, which, sending a "reverse" current, actuates a polarised annunciator in a derived circuit at the central office, thus signalling "off." This system has been in use for three years, and prevails in no other telephonic exchange. It elicited praise from M. Niaudet, of Paris, who has seen and examined it. It was devised and arranged entirely by Mr. Poole, electrician to the Lancashire and Cheshire Telephonic Exchange Company (Limited), at the head-office, Manchester. Now, in your issue of the 10th, there is a sketch and description of a new telephone switch bell. It is shown in your last issue to be the joint design of Messrs. Volk and Haworth, and claims to be original and part of a system described above. It would not have detracted much from the ingenuity of these gentlemen had they admitted that this feature in it was an adaptation and not an original invention. I would point out that it is a doubtful advantage to ring with the telephone off the hook, as the battery has then one cell short circuited through Blake primary, also that the hook does "make" and "break" bell and secondary circuits, not a shunt. After reading your last leading article on the "battle of the carbons," I looked up dates, and found that Edison's claim dates from July, 1877, whereas Professor Hughes's publication only dates from May, 1878.—Yours &c., D. F. D.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you please insert this in your next issue, in reply to Mr. W. Banks's letter on page 347. He is quite mistaken about the bell recently described being like the one he made ten months ago, and now in his possession. That bell has the ringing key springs in the cover, which is attached by four screws, these screws making the electrical connections between the springs and the rest of the apparatus. I at first made a similar apparatus for Mr. Haworth, and when we were talking the matter over we came to the conclusion that, providing room could be found, the springs would be best on the back of the case, as any electrician can see that testing for a fault was not simplified by having first to break four circuits in the bell. The result was I made the bell illustrated. I do not claim any invention in even new parts, but simply putting the same requisite parts into a more practical article from a commercial and electrical point of view. Take the case of the locomotive, those made forty years ago had practically the same parts, but I fancy the designers of modern engines can claim some little credit. Or, supposing I wish a house built, I might give the architect the size and number of rooms, where doors and windows, &c., had to be, but I fancy the architect and the builder would consider it their work.

I find from sad experience that if a sketch and description is handed to a manufacturer, who has then to work out the details, and make the whole into a practical thing, that what he, the manufacturer, has done counts for very little, and the sketch and description have done it all. Of course, if working drawings are given and followed the credit, or otherwise, does not rest with him.—Yours, &c., M. VOLK.

ACCUMULATORS AND MR. EDISON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Great importance will attach to Mr. Edison's statements quoted in *The Electrician*, Feb. 17, because they are his; but it appears to me that in this case the "Wizard of Menlo Park" is merely repeating what a few of our own countrymen have said many times during the last year. As long ago as December, 1881, accumulators formed the subject of a most interesting correspondence carried on between some of the electric companies and myself (at that time I was considering the question of fitting up my country house with incandescent lamps—a question still undecided); and among the letters I received was one from the manager of the Electric Light and Power Generator Company, dated Christmas Day, '81, in which the real state of affairs was for the first time pointed out to me in language as clear and certainly as forcible as that quoted in the last number of your excellent journal. I cannot decipher the gentleman's name, and the letter itself is too long to reproduce altogether; but if you think the following extract would interest your readers, perhaps you will see no harm in giving it a place in your columns:

"Why on earth wait until accumulators are perfected? It may take years to produce a thing that shall be worth its weight in lead, and I feel certain that long before the happy time arrives we shall have learnt to do better without them than with them. Believe me, accumulators are a delusion and a snare, and I fear that what has been said about them by persons whose one desire it is to make money by promoting companies will very seriously delay the introduction of electric lighting. Looking at the subject purely from the point of view of a mechanical engineer, I can think of no large scheme which cannot be carried out without the aid of secondary batteries. I grant that, if an *efficient* accumulator could be made for about £20 a ton, there are occasions when it might be *convenient* to use it, but, if cost is to be regarded (first cost, cost of attendance and renewals), duplicate engines and

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machines will always prove the cheapest. The larger the installation the more complete can it be made, and the less excuse there would be to use accumulators. Any one who will go into this matter fully and without sentiment will find that I am dealing with sober facts; if I might, however, be allowed to indulge in fancy I should be inclined to say that the accumulator of the present day is the invention of the devil."

Many persons have spoken to me in the same strain during the last twelve months, and I suppose there must still be a great deal of truth in the above statements, or we should not have them confirmed by so high an authority as Mr. Edison. I enclose my card, and remain—Yours &c., W.

London, W., Feb. 20, 1883.

THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 203.)

If the line is composed partly of a conductor A B (Fig. 47), having electrostatic capacity, and partly of the conductor B D, having practically no electrostatic capacity, then the

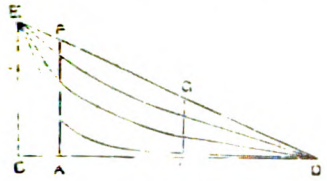

FIG. 47.

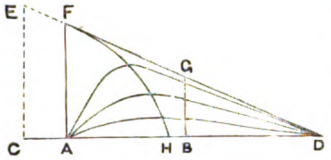

FIG. 48.

lines of potential at any moment during charging will form curves, with their concavity upwards in A B, and straight lines in B D; and in the same way, during discharge, the lines of potential will be curves with their concavity downwards in A B, and straight lines in B D (Fig. 48). The point of maximum potential will traverse a curve now terminating nearer to B than to A, and the greater the resistance of B D is in comparison with A B the nearer will the end H of this path

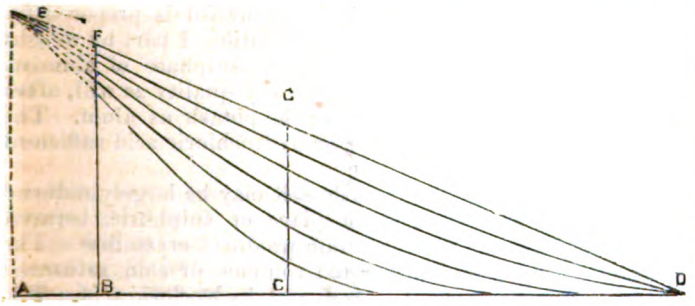

FIG. 49.

approach to B, but can never touch B, unless the resistance B D is infinite—*i.e.*, when the line is insulated at D. If the part B C (Fig. 49) of the circuit has no electrostatic capacity, and the part C D furthest from the battery has, then the lines of potential during charging will be straight lines in B C and curves in C D as shown in the figure. And during discharge the point of maximum potential will almost instantly change from F to G (Fig. 50), and then pass in a curve to some point H. The point H where the path of the point of maximum potential terminates will be much nearer to C (the junction of the electrostatic capacity conductor with the conductor of no electrostatic capacity) than that same point was to earth A in Fig. 41, showing that a greater portion of the charge now goes out at the distant end D.

We may in the same manner see that if we had a circuit, of which there were three parts, the two end ones having no electrostatic capacity, and the centre one having capacity, the potential lines at any moment during charging or discharging would be straight lines in the two end ones, and curves in the centre part.

Turning, now, to another subject—that of a circuit in which neither pole of the battery is to earth, but each connected to a conductor, having its other end to earth, it is useful to see how to draw the potential line in such case. Let A B (Fig. 51) be the resistance of the battery, B C one conductor to earth at C, and A D the other conductor to earth at D. Then, if A is the negative pole, we must erect at D the electromotive force D H, and joining H C, cutting a perpendicular at B, we get B E

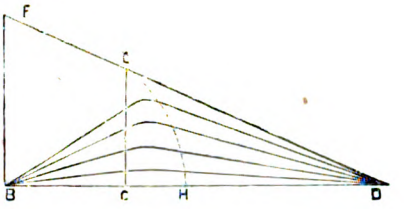

FIG. 50.

as the positive potential at B; and, drawing D F parallel to H C, cutting a perpendicular dropped from A, we get A F as the negative potential at A, from which, knowing our number of elements, it is easy, by dividing the line A B properly, to obtain the steplike series of lines which represent the potential line in the battery. If the line B C was removed and B L substituted, then in the same manner we should get the figure L O K D. It will be observed that, in the second case constructed, the line of potential is everywhere steeper than before, showing an increased current in the circuit. Also that, as the potential at B has dropped more than the potential at A has increased (negatively), the total difference of potential between the two poles has decreased.

If a perfectly-insulated battery has its poles connected by a well insulated line of similar electrostatic capacity throughout, then the point of no potential will be equidistant from each pole, or, in fact, in the centre of the line, and we might touch that point to earth without in any way altering the distribution of the potentials. But if the line has unequal capacity, then the point of no potential will no longer be in the centre of the line, but will be somewhere in the part that has the greatest capacity. Thus, if in Fig. 52 we suppose the circuit opened out in the battery, and B H resistance of battery and H E the electromotive force, proceeding as before we should get L C O D L as the line of potential if the conductor had equal electrostatic capacity throughout,

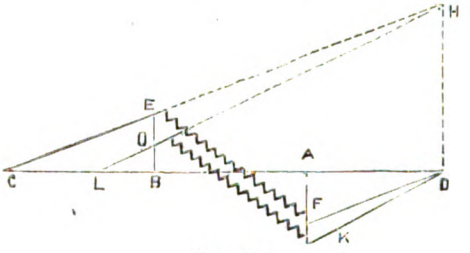

FIG. 51.

and O as the point of no potential, which we could touch to earth without producing any effect. But if O B was a conductor of considerable electrostatic capacity, and A O a conductor of no capacity, then the point of no potential would be at R, half-way between O and B, and the line of potential would be P M R N P. If, when O was the point of no potential, we touched the circuit to earth at R, the point of no potential would change to that point, and a quantity of electricity would be neutralised, represented by the parallelogram C M N D. Thus, if we had a perfectly insulated electric light circuit, with machine also perfectly insulated,* there will always, with a continuous current machine

* These conditions, I believe, rarely, if ever, exist, as the machines and lamps all leak, even if the lines are well insulated.

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and lamps in series, be one point which we can touch with impunity, but if we touched any other point we should receive a momentary current, produced by the discharge of a charge equal to the capacity of the whole line multiplied by the potential at that point. That point would then become the point of no potential, and could give no further shock until the point of no potential had, by touching some other part to earth, been transferred to that part. In an electric light circuit with lamps in series the primary or natural point of no potential will be in the centre of the resistance of the circuit, if the lamps are equally distributed along the circuit. But if they are connected all in one out-going wire, then the point of no potential will be in the return wire. As, however, electric light circuits in practice invariably leak fearfully the point of no potential will in reality always depend on the position of the resultant of all the leaks.

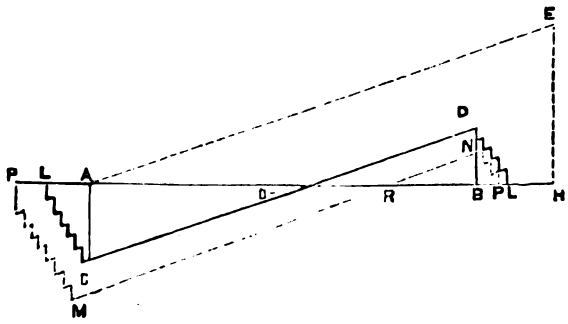

FIG. 52.

In a submarine cable in the factory tanks, when it is possible to insulate the battery perfectly, the distance of a fault having a very high resistance could be determined by measuring the potentials at A and B after the battery had been in circuit for such a time as to allow the point of no potential to move, as it would do in a short time, to the position of the fault, or resultant of the faults if more than one exists.

BICHROMATE OF POTASH IN BATTERIES.

BY. J. T. SPRAGUE.

The reactions of chromium are so complicated, and subject to such variation under changes of temperature and concentration, that it is by no means easy to be certain as to what occurs in these batteries. The usual solution is one of bichromate of potash with sulphuric acid, the proportions of which are very commonly given incorrectly, and should be different according to whether the solution is to be used in a porous cell, separated from the zinc, or as a single solution.

The salt itself is not a true double salt, like bisulphate of potash, which contains hydrogen as half the base, and is really a combination of sulphate of potassium and sulphate of hydrogen $\frac{K}{H}\}SO_4$. It is a union of potassium chromate with chromic anhydride, and its proper expression is $\left.\begin{matrix}K_2CrO4\\CrO_3\end{matrix}\right\}$. It is commonly supposed that the effect of the addition of sulphuric acid is to convert the potassium salt into chromic acid and sulphate of potash. But be the preliminary action what it may, the effect of the action of the battery is to convert the salt into chrome alum. The usual modern formulæ rather disguise this action, which is, however, quite intelligible when we regard an alum in the old fashion as a combination of a sesqui-sulphate $M_2^{iv}\cdot 3SO_4$, with a proto-sulphate M'_2SO_4 crystallising with 24 atoms of water. The tetratomic metal, uniting two atoms, so as to have a valency of 6, being either alumina, iron, chromium, &c., while the monatomic base is usually an alkali, potassium, or ammonium.

My unit of current, the "chemic," or 1 grain equivalent per 10 hours, affords a clear insight into these reactions and their electrical relations, and it should be understood that the term "unit" means in this paper that quantity or current corresponding to 1 grain equivalent of chemical action, and represents the coulomb or ampere divided by 5·68, according to the value accepted till recently that a coulomb represented ·0000122 gramme of hydrogen. The weights attached to the formulæ, therefore, mean grains for my purpose, and the reaction can be stated as

$$\left.\begin{matrix}\left.\begin{matrix}K_2CrO_4\\CrO_3\end{matrix}\right\} + 4H_2SO_4 = \left.\begin{matrix}K_2SO_4\\Cr_2(SO_4)_3\end{matrix}\right\} + 4H_2O + 3O\\ 295\cdot \quad 392\cdot \quad 567 \quad 72 \quad 48\\ 3Zn + 3H_2SO_4 = 3ZnSO_4 + 3H\\ 195 \quad 294 \quad 483 \quad 6\end{matrix}\right\} 3H_2O.$$

This represents 6 units of action, requiring in all 1 molecule or atom of the salt, 7 of acid, and 3 of zinc, to be consumed, or about 50 grains of bichromate per unit. Unfortunately, the electromotive force falls and the internal resistance rises as the alum accumulates, and owing to the insoluble nature of the materials, the solution is weak, and a pint of it is only equivalent to 25 units. However, to produce it the salt should be dissolved in hot water and allowed to cool, when it will contain about 3 ounces to the pint; it requires about one-sixth its volume of sulphuric acid, which is best used half at first and the rest when strength fails, and the acid must be employed in the proportions of 4 to 3, as shown in the formula if the zinc is in a separate porous cell.

The objections to this solution led Mr. FitzGerald to adopt the chromate of calcium, which ought to be obtainable at a price below that of the potash salt if there were a demand for it, but unfortunately it is not in the market, though for many purposes it would be fully as useful as the other. It can be made from the potash salt by dissolving 5 parts in hot water and adding 1 part of pure quick lime, slacking it just before use, and $2\frac{1}{2}$ parts of sulphate of lime (plaster of paris). A yellow powder precipitates, and its atomic weight is about 180, which represents about 60 grains per unit. It takes one atom more acid than the potash salt, the reaction being

$$\left.\begin{matrix}CaCrO_4\\CaCrO_4\end{matrix}\right\} + 5H_2SO_4 = \left\{\begin{matrix}2CaSO_4 + 3O\\Cr_2(SO_4)_3\end{matrix}\right\} 3H_2O.$$
$$3Zn + 3H_2SO_4 = 3ZnSO_4 + 6H$$

On the addition of the acid one-half of the lime is precipitated as sulphate, and the solution becomes a true bichromate or di-hydrochromate of lime, from which the remaining lime precipitates as the action proceeds. This solution can be made much more strong than the other, and does not crystallise. On the large scale it would have the advantage that its residues can be easily converted into valuable products as colours.

Another solution which might be useful is prepared by adding to 3 parts of bichromate in solution, 1 part by weight of oil of vitriol, and $6\frac{1}{2}$ parts of sulphate of alumina ($Al_2(SO_4)_3 + 18H_2O$), or so much of any quality as will, after concentration and cooling, remove the potash as alum. The solution will require sulphuric or hydrochloric acid sufficient to satisfy the reactions.

The objections to the potash salt may be largely reduced by using hydrochloric acid in place of sulphuric, because neither the zinc nor the chromium products crystallise. The solution can be made with equal volumes of cold saturated solution of bichromate of potash and hydrocloric acid. The reaction is probably

$$\left.\begin{matrix}K_2CrO_4\\CrO_3\end{matrix}\right\} + \begin{matrix}2HCl\\2HCl\end{matrix} = \begin{matrix}2KCl + H_2CrO_4\\H_2CrO_3Cl_2\end{matrix}$$

The formation of potassium chloride, chromic acid, and a chloro-chromic acid, which may be regarded either as a union of the hydro-chloric acid and chromic anhydride, or as chromic acid in which Cl_2 replaces one atom of oxygen. These now react thus—

$$\begin{matrix}H_2CrO_4 + 2HCl = CrCl_2 + H_2O + O_2\\H_2CrO_3Cl_2 = CrCl_2 + H_2O + O_2\end{matrix}$$

Giving 4 atoms of oxygen to take up the hydrogen derived from the action of 4Zn + 8HCl.

The complete reaction may be expressed also as

$$\begin{matrix}\left.\begin{matrix}K_2\\CrO_4\\CrO_3\end{matrix}\right\} + \left\{\begin{matrix}2HCl\\2HCl\\2HCl\end{matrix}\right\} = 2KCl\\ 295 \quad + \quad = 3H_2O + 2CrCl_2\\ 260 \quad 4Zn + 8HCl = 4H_2O + 4ZnCl_2\end{matrix}$$

511 HCl 14

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The use of hydro-chloric acid in place of sulphuric gives about 5 per cent. higher E.M.F., and the working is also more steady.

Voisin's red salt is useful in some cases, giving the same E.M.F. with a little higher resistance and a more constant current. It consists of

$$\underset{140}{Na_2SO_4} + \underset{686}{7H_2SO_4} + \underset{295}{K_2Cr_2O_7}$$

which is probably converted into

$$2NaHSO_4 + 2KHSO_4 + 2CrO_3 2SO_3 + 7\,\text{aqua}.$$

It is obtained by heating the acid, stirring in the sulphate of soda and then the bichromate of potash by degrees, then pouring into a mould to cool.

NOTE ON THE SUPERPOSITION OF CURRENTS.

BY THOMAS H. BLAKESLEY, M.A., ASSOC. M. INST. C.E.

The following generalisation is one which I have been for a long time in the habit of using in calculating the currents in various parts of a system of conductors, but I am informed that it is not given in the text books on electricity. This statement is true so far as I have been able to verify it; and even in Clerk Maxwell's treatise the rule is not given explicitly, though it may very likely be possible to find it involved by implication in some parts of that work. So, perhaps, it may be of interest.

If any reticulated system of conductors whatever contain at various points sources of electromotive force of different values, the resulting current in any conductor is always the algebraical sum of the currents which would be produced in that conductor by the different sources of electromotive force acting separately.

Thus, let Fig. A represent a system of conductors con-

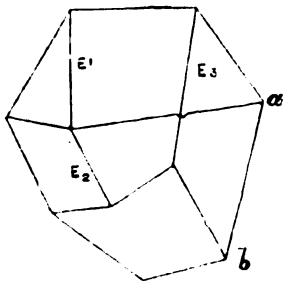

FIG. A.

taining at the points E_1, E_2, E_3, &c., sources of electromotive force which may be denominated by these letters. Now, considering any conductor *ab*, the rule asserts that the resulting current in *ab* is the sum of a number of currents which we may call c_1, c_2, c_3, &c., of which c_1 would be produced in *ab* supposing E_1 to maintain its value, but all the other sources of E.M.F. to be reduced to zero; and c_2 would be produced in *ab* supposing E_2 to maintain its value, but E_1 and all the others to be reduced to zero, and so on. That is to say, the effect of each source in producing an increase or decrease of current in any conductor is independent of the presence in the same system of other sources of E.M.F. And this is true, even if the conductor considered contain a source of E.M.F. It will also cover the case of leakage by conduction through the medium in which the system is situated, provided the resistance of the medium is constant, and, therefore, independent of the currents through it, and of the potentials producing those currents.

The cutting of any conductor carrying a current is equivalent in its effects upon the rest of the system to introducing a source of E.M.F. into the particular conductor, tending to send a current in the opposite direction to the actual current. For, let C be the current in a conductor, *ab*, of a system. Then it is clearly possible to suppose a source of E.M.F. introduced into that conductor which would reduce the current to zero. Suppose that this has been done. Then, since there is no current passing in the conductor *ab*, it may be cut without affecting the rest of the system, and when this has been effected the source introduced may be taken away from the end of the now divided conductor. Thus, the system has really only been modified by the division of the conductor *ab*, and this is equivalent to the introduction of an E.M.F. acting in opposition to C, the existing current, and of such a magnitude as to annihilate it.

Let there be six conductors (Fig. B) joined to each other like the edges of a tetrahedron or triangular pyramid.

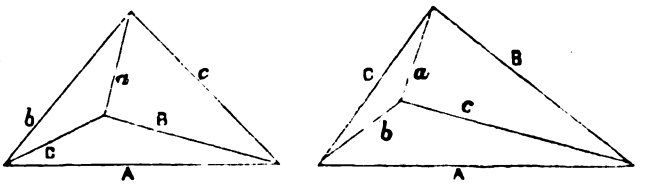

FIG. B.

Let the conductors A B C form one of the triangular faces, and let *a b c* be the three other edges which do *not* cut A B C respectively.

I shall also take these letters to represent the resistances of the various conductors.

Suppose a source of E.M.F. to exist in B. Then there will obviously be no current in *b*, if $a : c :: C : A$. Suppose this relation to exist, but instead of the source of E.M.F. being in B, let it now be in A. Then there will exist certain currents in *b* and B. Now cut B. This is equivalent to introducing an E.M.F. into B, as we have seen. But, by the rule of the superposition of currents, it does not *alter* the current in *b*, since it could not, acting singly, *produce* a current in *b*. Thus, the division of B does not affect the current in *b*, so long as $a : c :: C : A$, which constitutes Colonel Mance's method of finding the resistance of a source occupying the position of the source in A, the truth of which may be proved in other ways.

ON THE MEASUREMENT OF ELECTRICITY FOR COMMERCIAL PURPOSES.*

BY JAMES N. SHOOLBRED, B.A., M.I.C.E., &C.

Mr. Shoolbred began by stating that his remarks were more especially intended to deal with the commercial question raised by the Electric Lighting Act, 1882. He then described the various electrical units as adopted by the International Congress of Electricians, held in Paris in 1881, viz., the ohm, volt, ampere, coulomb, and farad, and those suggested by Dr. Siemens in his address to the British Association last year, viz., the watt and joule. Continuing, Mr. Shoolbred said: Although the unity of quantity, as defined, is the coulomb, yet it is sometimes found more convenient to express measurements of quantity in terms of the current or rate of flow in amperes. Thus, it is more convenient sometimes to say "one ampere-hour" than "3,600 coulombs," as the result of work done by a current of one ampere flowing continually and uniformly for the space of one hour. The product of the current expended, in ampere seconds, or of this amount of quantity expended in coulombs, by the electrical pressure of the same, expressed in volts, gives the electrical energy expended, or power of the supply expended in watts. The electrical energy is, therefore, represented by the product of volts × amperes × time; or, by the product of volts × coulombs; or, expressed algebraically, $W = E\,C\,t = E\,Q$. The following are the equivalent expressions for the same amount of energy, only expressed in other terms; some of which may, perhaps, be more familiar:—

Energy expended per second.

$$\text{Volt} \times \text{ampere} = \begin{cases} 1 \text{ watt.} \\ \frac{1}{1\cdot355} \text{ foot-pounds.} \\ \frac{1}{0\cdot81} \text{ kilogrammetres.} \\ \frac{1}{736} \text{ force cheval (French horse-power).} \\ \frac{1}{746} \text{ horse-power, indicated.} \end{cases}$$

It is suggested in some of the (draft) provisional orders for the supply of electricity now before the Board of Trade, that the

* Abstract of a Paper read before the Society of Telegraph Engineers and of Electricians, Feb. 22, 1883.

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unit of price to be charged should be based "on the energy contained in a current of 1,000 amperes flowing under an electromotive force of one volt during one hour;" or, in other words, the unit might be put as 1,000 volt-ampere-hours. Since the ampere-hour is another way of saying 3,600 coulombs of quantity of electricity supplied, this above expression may be put thus, as representing the value of the about unit:—

Work Done.

1,000 volt-ampere-hours = { 3,600,000 volt-coulombs. / 1,000 watt hours. / 1·34 horse-power hours. / 2,653,200 foot-pounds. / 1·36 force-cheval-heures (French horse-power hours nearly). / 100 kilogrammetres.

Put in terms more in accordance with actual practice, the above unit might mean the supply for one hour of a current of 10 amperes with an electromotive force of 100 volts. To arrive at a due evaluation of the supply of electric energy, it is evident that the measurement of each of these two factors (in volts and amperes respectively), should be effected either separately or combined; and also that a continuous and cumulative record should be kept of the supply as it proceeds. Many instruments exist for the measurement of the above elements, at any particular time, but without any means of continuously recording such measurements. These evidently, except under certain conditions, cannot comply with the commercial conditions required for ascertaining the amount of supply. It is only, therefore, instruments furnished with means of continuously integrating, or recording the successive progressions of the supply, or instruments to which such recording apparatus can readily be attached, that come properly within the scope of this paper. To measure with completeness for commercial purposes a supply of electricity will entail, therefore, a continuous record of each of the two elements just referred to—current and pressure, either separately or combined. In the supply of towns, however, the question for the consumer may, and will most probably, be much simplified by causing one of these elements—that of pressure—to remain constant, since it is very likely that a constant standard pressure of supply will be fixed by the Government in granting the several provisional orders. It has been thought advisable to precede the description of the recording or registering instruments, which alone are meters in the commonly accepted sense of the word, by an enumeration of some of those non-recording instruments which are in more general use, since they suffice for present exigencies. This short descriptive enumeration is even almost necessary, since most of these instruments, by the addition of some recording apparatus, or appliance by which the element of time can be integrated, may be made to enter into the class of registering meters. Indeed, some of them already possess their representative in this second class, or else have given rise to some modification which has complied with the requirements in the latter case. Thus, any current or ampere measurer may be converted into a record of quantity, or a coulomb meter, by the integration of the time during which the current has flowed, and, similarly, any power or volt-ampere measurer may become a register of work done by means of the addition of the elements of time. Again, volt or pressure measurers will always be required in any case where a check is required upon the actual difference of potentials, or electromotive force of the supply, and this may arise from a variety of causes.

NON-REGISTERING INSTRUMENTS.

Current Meters.—Siemens', electro dynamometer; Professors Ayrton and Perry, am-meter; Sir Wm. Thomson, current galvanometer; Captain Cardew, R.E., low resistance galvanometer; Dr. Obach, tangent galvanometer; Marcel Deprez, galvanometer.

Pressure Meters.—Profesors Ayrton and Perry, volt-meter; Sir Wm. Thomson, potential galvanometer; Siemens', torsion galvanometer; Marcel Deprez, galvanometer.

Power, or Energy, Meters.—Professors Ayrton and Perry, power meter; C. V. Boys, power meter.

REGISTERING METERS.

Quantity, or Colomb, Meters.

1. *Electrolytic.*—T. A. Edison, total deposition; T. A. Edison, alternations of deposition; J. T. Sprague, alternations of deposition.

2. *Mechanical.*—Dr. J. Hopkinson, rotating meter; C. V. Boys, vibrating meter; Theos. Varley and Greenwood, disc meter; Professors Ayrton and Perry, fluid friction on magneto-electro-motor; T. A. Edison, fluid friction on magneto-electro-motor.

Energy, or Work, Meters.—Professors Ayrton and Perry, erg-meter; C. V. Boys, energy meter; Deprez-Abdank, energy meter.

Mr. Shoolbred here entered into a description of the principle and working of some of the above-named meters, amongst others those of Edison, Sprague, Boys, Ayrton and Perry, and Hopkinson. Of these, all but the latter have been previously described in *The Electrician*.* Of Hopkinson's current meter, Mr. Shoolbred said: This instrument consists of a thick wire coil, in the form of a solenoid, through which the current passes to be measured. The iron core of this solenoid revolves with its central shaft by the action of the armature of a small dynamo machine, placed at one end of the shaft. The core of the solenoid is in two parts; the lower is fixed to the shaft, while the upper is movable, being attached to a governor-ball arrangement, and sliding up and down the shaft in accordance with the variations in the rotation speed of the shaft. A shunt current passes through the dynamo and its armature, then up through the lower or fixed portion of the core, and (by contact only) to the sliding part, and thence to the framework of the apparatus. If the movable core be lifted, owing to the speed of rotation by the action of the governor balls, this circuit is broken, and the shunt current through the dynamo interrupted. Whenever a current to be measured passes through the coil, attraction, by means of its casing, takes place between the fixed and the movable parts of the iron core. This magnetic action, which is proportional to the square of the current, tends to keep the two parts of the core together and in contact, while the centrifugal force of the governor balls, which is proportional to the square of the speed of revolution, tends to break the contact by lifting the movable part. These opposite forces will, in working, balance one another, and the result is that the system revolves with a velocity proportional to the current through the coil. As the revolutions of the shaft are transmitted continuously by a train of wheels to a set of index dials, a record is thus kept of the quantity of the current that has passed. In the construction of the apparatus the weight of the core is taken off by springs.

In conclusion Mr. Shoolbred said:

For the reasons stated in the earlier part of the paper, it is probable that the supply of electricity in a town will be carried out at a certain defined standard pressure or electromotive force, which will be guaranteed to the consumer; and to assure the fulfilment of this condition special steps will be taken by the local or other authority.

The consumer need, therefore, but concern himself, as far as the supply he receives and has to pay for, with the quantity of electricity which he has made use of. In fact, the meter he makes use of to record it may be a coulomb meter. The work or energy meters will not be needed for general application, but only in special cases, where the complete record of the total electrical energy supplied is required.

In what form, therefore, will it be most convenient for these coulomb meters to present their record? or, in other words, upon what unit should that register be based for commercial calculation? With the sole exception of those meters based upon electrolytic action, and which simply present the total of the increments of the metal, which are proportionate to the total quantity of current which is passed, the record presented is the result of a series of mechanical actions indicative of the strength and duration of the electrical supply.

It is seen how these successive mechanical operations may be recorded in a cumulative way by the ordinary arrangement of a train of wheels; both in the case of those meters based upon electrolytic action, and causing periodical reversals in the direction of the current, and also in those where the action due to the current is a purely mechanical one.

There remains then but the question of the mode of graduation of the respective indicating dials.

The unit already referred to, as being proposed to the Board of Trade in several provisional orders, as "the energy in a current of 1,000 amperes with an electromotive force of one volt flowing during one hour," has been shown to mean 1,000 volt-ampere-hours, or 3,600,000 volt-coulombs.

As it is probable that one of these factors (the volt) being fixed and constant may be taken out of the commercial calculation for the consumer, it is worth while considering what dimensions the remaining factor (the coulomb) would assume under the ordinary conditions of practice, and, hence, what would be most convenient graduation of the dials to embrace these dimensions. But the commercial question requires also a financial expression in which to reckon these dimensions.

The maximum money value accompanying the suggestion of the above 1,000 volt-ampere-hours unit, and which is sought to be attached primarily to 100 of these units, is in some pro-

* Descriptions, with illustrations of these meters, will be found in *The Electrician* as follows:—Ayrton and Perry's meters, Vol. IX., pp. 373 and 413; Sprague's meter, Vol. IX., p. 67; Edison's meter, Vol. IX., p. 65; Boys's meter, Vol. VIII. p. 251.

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visional orders 70s., in others 75s. Though it would be quite out of place in this paper to attempt to assign any financial value for the supply of electricity, yet for the nonce, and in carrying out the analysis of the above unit—as it might work under the conditions of actual practice—it is necessary to assume a money value. In the annexed table, which takes into consideration the effect of different rates of electromotive force according as they may be fixed, 70s. is assumed as the money value for 100 units of 1,000 volt-ampere-hours each.

Comparative Values of Supply of Electricity per 100 *Units* (*of* 1,000 *V.-A.-hours*) = £3 10*s.*

(1,000 volt-ampere-hours = 3,600,000 volt-coulombs.)

E.M.F. Volts.	Price. 100 Coulombs.	10,000 Coulombs.	100,000 Coulombs.	1,000,000 Coulombs.
	Pence.	Pence.	s. d.	£ s. d
100	·23	2·33	1 11·3	0 19 5
110	·26	2·57	2 1·7	1 1 5
120	·28	2·8	2 4	1 3 4
130	·3	3·03	2 6·3	1 5 3
140	·32	3·27	2 8·7	1 7 3
150	·35	3·5	2 11	1 9 2
160	·37	3·73	3 1·3	1 11 1
170	·4	3·97	3 3·7	1 13 1
180	·42	4·2	3 6	1 15 0
190	·44	4·43	3 8·3	1 16 11
200	·46	4·67	3 10·7	1 18 11

The prices in this table are based on the assumption that the price per coulomb unit remains at the same rate, irrespective of the intensity of the electromotive force. As a matter of fact, the amount of the latter ought certainly to be taken into account in fixing the sale price.

Thus, with a pressure at 200 volts, the price for a certain number of coulombs ought not to exceed two-thirds of that of the same supply at 100 volts of pressure; in consequence of the economy in the former case, in the distributing mains, and in general working expenses.

From a careful consideration of this table, it would appear that the amount of 100,000 coulombs would form a convenient unit of value whereby to reckon the commercial price. It would also serve as a basis of graduation for the indicating dials of the meters, with subdivisions to $\frac{1}{10}$ and $\frac{1}{100}$ parts.

The diagram (shown at the meeting) gives an arrangement of indicating dials, graduated in the first case with the unit suggested in the provisional orders, 1,000 ampère-hours; in the second the unit is 100,000 coulombs as just suggested. The E.M.F. in each is taken at 100 volts. The proportion between the two systems of graduating in the present instance is as 3·6 to 10 (3,600 being the number of coulombs which is the result of the flow of a current of one ampere for one hour).

$\frac{3{,}600{,}000 \text{ coulombs}}{100 \text{ volts}}$ is, therefore, the actual quantity value of the first unit (1,000 ampere-hours), as against 100,000 coulombs, the quantity contained in the second unit.

The values in C.-G.-S. units are { Volt-ampère-hour unit = 10^{10}. Coulomb unit 10^{4}.

The advantage of the coulomb unit is that it expresses an actual quantity, whereas the ampere-hour unit is but a time rate, which, as a matter of fact, has to be translated into its corresponding quantity.

The coulomb method of graduation could be applied *uniformly* to all quantity meters whereon they might happen to be afterwards used, inasmuch as the special rate of electromotive force (or standard pressure) in each particular locality would be taken into account in the price there charged for the electric supply. This uniformity in manufacture would further reduce the expense of this, already the simpler, form of registering meter.

With the volt-ampere method, to use a quantity meter (as shown in the index-dial diagram) requires the exact position of the unit to be set according to the particular electromotive force with which it is used; inasmuch as the quantity-record is only one factor in the unit. This limited use of each particular recording meter would tend to create error and confusion.

An energy meter alone would supply a complete record of the volt-ampere-hour mode of measurement; and this is a form of meter which involves a clock or some other time record, and consequently is a more expensive apparatus, and one requiring an amount of attention from the consumer which it would be impossible, in many cases, to expect.

Thus, although the volt-ampere system may present, *theoretically*, a complete and convenient means of recording the supply of electricity, yet, *in actual practice*, the coulomb system would meet all wants, and be more suited to general application.

ON ELECTRIC LIGHTING FOR WORKSHOPS AND LARGE SPACES.*

By Mr. Andrew Jamieson, A.M. Inst. C.E., F.R.S.E., &c., Principal, College of Science and Arts, Glasgow.

(concluded from page 354.)

The connections of the Brush machine have hitherto been considered rather a mystery, but I hope that the theoretical diagram given in Fig. 4, along with the following description, will make them clear to you. The armature coils A A and commutator parts C C are shown in the diagrams at right angles to their position in the machine, with a view to facilitate tracing the connections. The opposite coils, whose inner ends are connected together, are numbered (1 − 1′), (2 − 2′), (3 − 3′), and (4 − 4′), while the opposite plates on the commutator to which the coils are respectively connected are similarly marked. Starting from armature coils (3 − 3′) and following the direction of the arrows which indicate direction

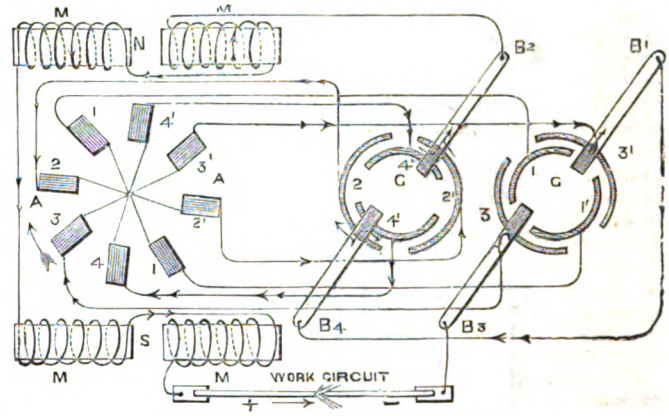

Fig. 4. Diagram of Brush Machine.

of current, we come to commutator plate 3′ to brush B_1, then to brush B_4, where the current splits at plates 2 and 4; by 2 to coils (2 − 2′) to plate 2′ and by 4 to coils (4 − 4′) to plate 4′ where brush B_2 unites the currents again and leads them to the electro-magnates M M M M, through which it passes to the (+) carbon or work circuit across the arc where light is produced, and along the (−) carbon to brush B_3, commutator plate 3, back to armature coils (3 − 3′), thus completing the circuit. It will be seen that each pair of coils as they come into the position (1 − 1′) are cut out of circuit, thus reducing the armature resistance mentioned before.

The Crompton-Bürgin Dynamo is a very practical and useful modification of the Gramme dynamo. It is constructed either for arc lighting or for incandescent lighting purposes. When constructed for the latter work, the electro-magnets are specially wound on the combined series and shunt principle, with the view of rendering the generation of the current automatically proportional to the number of lamps in circuit, and keeping the electromotive force constant for a constant speed.†

This machine has several advantages—1. It lies low, is well constructed, and free from vibration. 2. Armature coils easily made and repaired. 3. The armature admits of being accurately balanced and rapidly rotated. 4. The small number of *layers* of wire on armature rings, with a free circulation of air *between* the spokes, prevents undue heating.

We may here state that all dynamos on important circuits should be fitted with accurately indicating tachometers, or continuous speed indicators. This is a point which is too often neglected, although it greatly assists those in charge in keeping up a steady motion.

Conducting Wires or Leads.

These should, in all cases, be carefully proportioned to the strength of the current they may have to carry, and to the distance through which it has to be conveyed; for, when electricity flows through resistance, energy is spent in heating the matter through which it flows. For practical use, the heat generated by a current of electricity in time $T = C^2 R T \times 0{\cdot}2405$ (gramme degrees), where C = amperes, R = ohms, and T = seconds. Hence it is that if the conducting wire be too small for the current it has to convey, it will become warm, which still further increases its resistance—ultimately producing incandescence, and even fusion, endangering property by fire. Again, although the wire may have sufficient conducting power for the current, without undue heating at any part, yet its length, and consequently its resistance, may be so great that the total amount of heat generated, or energy misspent on it, will much reduce the efficiency of the system. (The rules laid down in the new Electric Lighting Draft Provisional Order were read and commented upon.)

Arc Lamps.

In dealing with electric lighting for workshops and large spaces, I need only consider arc lamps, as neither the incandescent nor semi-incandescent lamp is so suitable as yet. I shall describe a few of them in the alphabetical order of their names.

Akester's Lamp is one of the simplest forms of arc lamps that I have

* A Paper read before the Institution of Engineers and Shipbuilders in Scotland.

† A description of the principle of this machine appeared in the issues of *The Electrician* for December 16, 30; January 13, 27.

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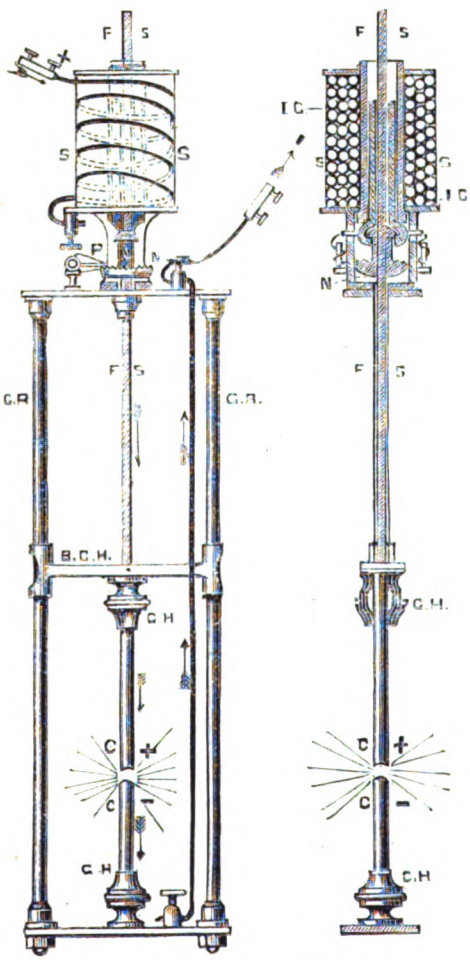
met with. It is only arranged to be worked as a single lamp, but there would be little difficulty in so winding a shunt coil, and fitting the extra necessary parts to it, as to make it serviceable to be worked in series with a large number of others of the same kind. Most of the modifications of arc lamps, of which there are so many patents, aim at keeping the + and − carbons at a uniform distance when in action, to produce a steady light. This is generally done by combined electrical and mechanical action.

Referring to Figs. 5 and 6, we see

S, S,	Solenoid coil of copper wire, No. 10 B.W.G., insulated by cotton and shellac varnish.
I, C,	iron core (hollow).
F, S,	quickly pitched six-threaded screw.
N,	nut with lower upturned edge milled.
P,	pall or lever held down by a bent spring.
C, H,	carbon holders.
C + C −	carbons 13 millimetres diameter.
G R, G R,	parallel iron guide rods.
B C H,	brass crosshead.

In this lamp the current, in passing from the dynamo to the upper carbon, traverses the solenoid coil S S, acting inductively on the hollow iron core I C, and sucking it upwards, thus lifting the upper from the lower carbon by engaging the nut N, which is fitted to the central screw F S. The milled edge of the nut comes against the lever pall P, and is thereby prevented from turning round, thus limiting the length of arc.



FIGS. 5 and 6.—Akester's Lamp.

As the arc burns longer the resistance of the circuit increases, the current thereby necessarily diminishes in strength, and the lifting power of the solenoid becomes less, allowing the iron core to drop a minute distance, just sufficient to clear the milled edge of nut N from the pall P, the nut turns round through a degree or so, which allows the carbon to drop a very small distance, the normal length of arc being in this way resumed. The above operation takes place so rapidly that the upper carbon is fed forward in almost perfect unison with the consumption, ensuring a steady light.

From tests which I made of this lamp an actual, not nominal, candle power of 2,250 candles, or 1,450 candles per horse-power at the lamp was obtained, the electricity being furnished by an A Gramme dynamo.

I would like here to explain and clear up an ambiguity which has arisen and which is very confusing to those not acquainted with electrical phraseology. When the expression, so many candles per "electrical horse-power," or so many candles per horse-power expended in the lamp, is used, it is to be understood that the electrical energy absorbed by the lamp, and developed in the form of heat and light, is according to the formula $\frac{E \times C}{746}$ (which we stated at the beginning of this lecture was an actual horse-power of 33,000 foot-pounds per minute). This takes no account whatever of the energy lost in transmission through the leading wires, or that absorbed by the dynamo, or that spent on the moving parts of the engine shafting and belting through friction, &c. It is considered fairly good work, in actual practice, if we get 60 per cent. of the horse-power, as indicated by diagrams taken from the steam cylinder, in the form of electricity, at the lamp carbons or arc. The loss of power in conversion and transmission may be roughly computed as follows:—

Loss by friction, &c., in engine, &c.	10 per cent.
,, in conversion of mechanical to electrical energy in dynamo, by heating, friction, &c.	20 ,,
,, by heating leading wires and lamp circuit coils	10 ,,
Total loss	40 ,,

One has, therefore, always to be on guard when inquiring "how much power such and such a lamp or system gives in the form of light;" and it is generally necessary to ask the question, "Do you mean so much cylinder horse-power, or so much dynamical horse-power, or so much in the form of electrical energy at the lamp?"

*Brush Lamp.**—Perhaps no lamp has been so extensively adopted as the Brush lamp in workshops and streets. Its popularity and success mainly depend upon the fact that it is arranged so that a large number can be included in series and worked from one dynamo. As many as 40 of these lamps have been worked, in numerous instances, by one machine, while the whole system is so adjusted by means of an automatic carbon regulator that one or more of the lamps can be extinguished or removed without endangering the others remaining in circuit. The only danger arising from using such a large number of lamps in circuit, placed in series, is the necessarily high electromotive force of the current. The normal electromotive force or difference of potential between the terminals of each lamp being 45 volts, 40 such lamps, *irrespective* of the leading wires and dynamo, require an electrical pressure of 1,800 volts, or about 2,000 volts including the dynamo and leads; and, therefore, the connections and leading wires should be well insulated, and the handling of the same should be done with care and caution. The normal strength of current is 10 amperes, so that each lamp absorbs energy to the amount of $E \times C = 45 \times 10 = 450$ watts.

I tested the candle-power, the other day, of one of the Brush lamps at the Aberdeen installation, where they have dispersed along Union-street, Market-street, &c., in a circuit of a mile and a half, 16 lamps of 2,000 (nominal) candle-power, and found it to give 567 candles, measured at an angle of 30 degrees from the horizontal. The lamps are placed on 20ft. wooden poles, and the centre of the arc of the one which I measured was 20ft. 10in. from the ground, which appeared to be a very suitable height for distributing the light. The lamp was fitted with clear glass globes, which, from various tests which I have made with clear glass, will reduce the candle-power about 10 per cent. of that given by the naked light. I also tested one of the 32 Brush lamps daily at work at Messrs. Mirrlees and Watson's engine works, where they use strongly frosted globes with a view to soften and diffuse the rays of light and render it more agreeable to work under. These globes reduce the candle-power about 50 per cent., and the mean which I got was 310 candles. The workshop engine is used, and it appears that 17 lamps are worked by one machine for an expenditure of 19 indicated horse-power, as measured by diagrams taken from the cylinder; or, say roughly, 1·1 indicated horse-power per lamp, or 54·5 per cent. of the horse-power developed in the cylinder is usefully employed in the form of electricity at the lamps.

The Crompton Arc Lamp.†—This is very suitable for railway stations and large spaces where a powerful light of 2,000 or more candles is desirable, and where plenty of elevation can be obtained.

Messrs. Crompton's firm state that they obtain by this lamp effective lighting for 200 square yards of station floor area, both at Queen-street Station, Glasgow, and King's Cross Station, London, for an expenditure of only one pound of coal per hour by using Messrs. Marshall and Son's economical engines. You have, no doubt, all witnessed the performance of this lamp at Queen-street Station, Glasgow, and I think every one admits that it is the best-lighted station in the kingdom. Mr. Hobson, the postmaster, is so well pleased with this lamp at the General Post Office that he has entered into a two years' working contract for the lighting up of the large spaces in the Post Office, while the smaller offices and rooms are to be lighted, within a couple of weeks, by means of Swan lamps.

I think arc lamps, both in railway stations and workshops, should be so placed with regard to distance apart and height that no part where work or business has to be carried on should have less light than that equal to one standard candle at 2ft. distance. For the Brush lamp, reckoning them as averaging 500 candles with clear globes, this would mean placing them at a height of 22½ft. and 26 yards apart, and would give a good light to read or work by, while not too strong or trying to the eyes. For streets, the Brush lamps might still be placed at a height of 22½ft. and about 60 yards apart, or with a minimum light at the further parts from the lamps of about equal to 1 candle at 4ft. distance. In workshops, streets, and large spaces, the lamps should be so placed zig-zag that the light from each tends to dispel or cancel, as far as possible, the shadows cast by the others.

It is worthy of mention that Messrs. A. and W. M'Onie, who have lately adopted the Brockie lamp (which was shown at the meeting), are able to photograph their working drawings by means of the electric light. They have fitted up a special room for the purpose, and obtain a clearly defined copy of a drawing 3ft. 6in. by 2ft. 6in. in twenty minutes.

Electrical Instruments for Measuring the Strength of Current and the Electro-Motive Force.

The development of electric lighting has necessitated the invention of special instruments for measuring stronger currents and greater electrical pressures than were demanded by those used for submarine and other telegraphic and scientific purposes, and we are fortunate in being able to place before you this evening the latest and best that have yet been produced, viz.:—Sir William Thomson's graded galvanometers, made by Mr. White, the well-known optician of Sauchiehall-street. (These instruments, and methods of using them, were described to the meeting.)

* A diagram, illustrating the action of this lamp, was given in Vol. IX. of *The Electrician*, p. 486.

† We have frequently illustrated the Crompton arc lamp. The latest improvements in its mechanism and working will be found illustrated and described in our issue for November 4, 1882, Vol. IX., p. 586.

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Relative Cost of Electric and Gas Lighting for Workshops.

We now come to compare the cost of electric lighting and gas lighting.

There can be no doubt that the introduction of electric lighting has greatly spurred on inventors and gas managers to make more of the gas than formerly, and the consequence is that we have gas burners rivalling the electric light both in brilliancy and economy.

There are being fitted at the present moment to the Clyde Navigation Graving Dock a large number of Bray's powerful gas lamps. Also, the Clyde Trust has in operation one of Siemens's 400 candle-power lamps, and is having fitted up 20 of Siemens's patent regenerative 130 candle-power gas burners, in place of the former mode of lighting by 30 cowl-shaped crystal basins, each containing four No. 4 gas jets. Each of these systems of gas lighting has certain advantages which the other does not possess, and for each certain advantages are claimed against those of electric lighting. There can be no doubt but that the Siemens burner is more economical than Bray's, as far as the amount of light given out for a certain consumption of gas, for it is found that while the Bray lights give 5·7 candles per cubic foot of Glasgow gas, the Siemens burner—as we shall prove further on—yields 7·8 candles per cubic foot of the same gas; but then the Bray lights admit of being turned down to one small jet, when the full flame is not required, more readily than the Siemens burner.

From tests made by Dr. Wallace and myself of these Siemens burners, it appears that 408 candles are obtained from a consumption of 52·2 cubic feet per hour, or 7·8 candles per cubic foot; or, say, 39 candles for 5 cubic feet per hour, or an improvement in the economy of using gas of 46 per cent. over that of the best small burner which is used in testing the Glasgow 26-candle gas (*i.e.*, 26 candles for 5 cubic feet per hour).

Let us compare this with the Brush lamp under similar conditions as to globes and lanterns. We got 567 candles from the Brush lamp at Aberdeen, with clear globes.

Cndls. Cndls. Cb. ft.
∴ 408 : 567 :: 52·2 : X = 72·5 cubic feet per hour.

of Glasgow gas required by Siemens's burner to produce 567 candles. Now Glasgow gas costs 3s. 8d. per 1,000 cubic feet.

Cb. Ft. Cb. Ft. D
∴ 1000 : 72·5 :: 44 : y = 3·19d. for gas alone per hour.

To this we have to add, say, 20 per cent. on first cost of lamps and fittings (£30), as well as depreciation on same—or £6 per annum. Allowing this to be distributed over 3650 hours, or 10 hours' lighting per day, we have

Hours. Hour.
3650 : 1 :: 1,440d. : Z = 0·39d. per hour

for interest and depreciation of plant. We have also to count something for attendance, and this cannot be reckoned at less than one farthing per hour per lamp. Adding these sums, we have

3·19d. per hour for gas.
0·39d. ,, ,, interest, &c.
0·25d. ,, ,, attendance.

Total cost, 3·83d. per hour.

And this with by far the most economical method yet devised for burning gas.

I understand that the Brush Company of Scotland are willing to lay down all the necessary plant, including steam boiler, engine, dynamo, leads, pumps, &c., complete, and guarantee their proper working, paying all expenses, including, carbons, &c., for a system of 40 arc lamps, to any person or combination of persons within reasonable distance of each other, and charge them only 3d. per hour per lamp during every 3,650 hours of lighting per annum. This is a straightforward and practical way of putting it; and should the lights be required for a proportionately less time per annum than the 3,650 hours, they will be able to tell you the small fractional extra expense per hour which it will cost.

Since the meeting I have been informed by Messrs. Bray and Co. that the price per hour for each of their 500 candle-power gas lanterns burning in Glasgow, at full power, for 2,000 hours per annum, would be 4·375 pence. This estimate includes erection, interest, and maintenance of plant in good working order. If, however, their double service system be adopted—that is, lowering the lamps at midnight to one jet of 30 candles (or 1,000 hours at 500 candles, and 1,000 at 30)—the price is reduced to 2·875 pence per hour per lamp. The above does not include lamplighters' wages, which we may reckon at one farthing per hour per lamp.

THE ELECTROLYTIC BALANCE OF CHEMICAL CORROSION.*

This paper treats of some fundamental points in silver electro-plating, and shows how a large amount of the electric power may be wasted by the use of too large a proportion of free potassic cyanide in the plating solution, or by using the liquid in a heated state.

In it is also described a method of ascertaining the degree of energy of chemical corrosion of metals in electrolytes, by means of the strength of electric current per unit of surface necessary to prevent such corrosion; the metals and liquids employed for the purpose in the present research being silver, and solutions of argento cyanide of potassium containing free potassic cyanide. Numerous examples, chiefly in the form of tables, are given of the strength of current required to enter cathodes of a given amount of surface, in order to exactly balance the chemical corrosive effect upon them at atmospheric temperatures, and at higher ones, of solutions of potassic cyanide of various degrees of strength.

The method employed was to take a given solution of cyanide of potassium, pass through it, by means of a sheet of platinum anode and a burnished sheet of silver cathode, a weak electric current, and add gradually to the liquid (with stirring) small portions of argento potassic cyanide, until the faintest perceptible deposit of silver occurred. The verge of deposition thus attained was called "the balance point;" and the conditions which determine and influence it, constitute the subject of this research.

* Abstract of a paper by G. Gore, LL.D., F.R.S., read before the Birmingham Philosophical Society.

The effect of various conditions upon the point of balance of electric and chemical energy were investigated, and the experiments are described. The influences examined were: Composition of the liquid, strength of current, size of cathode and density of current, electromotive force, temperature, ordinary chemical corrosion, nature of the cathode, &c. The circumstances were also investigated which affect the measurement of the current by the method employed in this research, viz., by depositing silver from a solution of argento potassic cyanide; and the sources of error (and their limit), in that method, are pointed out. The effect of varying the proportions of free potassic cyanide, and of argento potassic cyanide, upon the strength of current at the balance point, are shown in tables of results. The strengths of current just sufficient to prevent all corrosion and to deposit the whole of the silver from a solution of argento potassic cyanide of given composition and containing free cyanide are also shown. The influence of varying the proportions both of argento potassic cyanide, and free cyanide of potassium, upon the transfer resistance* of the solution, and thereby upon the balance point, are also investigated and the results described.

A number of results and conclusions were arrived at, some of which are as follows:—Variation either of the number of battery elements, the proportion of water, of free potassic cyanide, or of argento potassic cyanide, destroys the balance. The effect of altering the proportion of water is opposite with strong solutions to what it is with weak ones. The electric current at the point of balance appears to be entirely conveyed by the free potassic cyanide, and does not divide itself between the two salts until the liquid contains a certain proportion of argentic salt. In strong solutions of potassic cyanide, decreasing the number of battery cells, necessitates more cyanide of silver to restore the balance. The alteration of the point of balance by alteration of proportion of free potassic cyanide cannot be much accounted for by alteration of corrosive power of the liquid. A current from ten Smee's elements is about sufficiently strong to prevent all corrosion of silver at 60 deg. F. in a solution of cyanide of potassium containing a mere trace of argento potassic cyanide. The addition of nitrate, chloride, iodide, or sulphate of potassium to the cyanide solution has but little effect upon the balance point. Variation of strength and of "density" of current affect greatly the point of balance. Greater "density" irrespective of strength of current usually increases the amount of silver deposited. Difference of electromotive force of current had no conspicuous effect in altering the balance point. Rise of temperature of the liquid acts in two opposite ways, it increases the corrosive action, and by diminishing conduction-resistance it increases the current, and as the latter effect is usually a little stronger than the former one, rise of temperature alters slightly the point of balance, and enables the current to produce a sparing deposit of silver. The ordinary chemical corrosion of silver in a solution of potassic cyanide without an electric current is increased slightly by partial immersion (through capillary corrosion), and greatly by rise of temperature; it is also slightly greater in a weak solution than in a strong one, with solutions of a certain range of strength; and it is distinctly increased by contact with platinum. In consequence of the latter circumstance, a platinum cathode requires a somewhat stronger current than a silver one to enable the point of balance to be attained. In a mixed solution of potassic and argento potassic cyanides, even the smallest proportion of the former salt conveys a portion of the current, and if the cathode is large or the current is sufficiently weak, the whole of it is conveyed by that salt, however much of the double salt is present. An error is thereby introduced when deposition of silver in such a liquid is used as a measure of current. But with a large amount of the double salt, a small amount of potassic cyanide, and a current sufficiently strong, the proportionate amount of error is small. During the act of deposition the cathode surface is not at all corroded, and any deficiency in the weight of deposit is not due to corrosion, but to a portion of the current being conveyed by other ingredients of the liquid than the argentic salt. A current which produces deposition of silver, prevents all corrosion of a silver cathode in the same liquid. The addition of free potassic cyanide to a solution of the double cyanide alters both the resistance and the balance point. The quantity of current diverted from the argentic salt in solution is directly proportional to the amount of free potassic cyanide present, but not always in the same ratio. The presence of a large proportion of free cyanide, together with the employment of a feeble current conduce to the passage of a large amount of current through the liquid without depositing silver; and a current of ·001057 ampere (which would deposit ·132 grain of silver in two hours) was hardly strong enough to prevent all corrosion or to deposit any silver from a solution composed of 37·5 grains of argento potassic cyanide and 112·5 grains of free cyanide of potassium in three ounces of water. Whilst also a current if sufficiently weak, may traverse a solution of potassic cyanide containing double cyanide, without any of the current decomposing the latter, it cannot traverse a solution of double salt containing free potassic cyanide without some of it traversing the cyanide of potassium. With a very dense current also, a portion of it enters the cathode without depositing silver, and evolves gas.

It requires a much stronger current to balance the corrosion in a hot solution of the two cyanides than in a cold one, and in an instance given, a rise of temperature from 60 to 120 deg. F. was attended by the passage of 21 per cent. increase of current without deposition of silver. Addition of free potassic cyanide to a weak solution of the double salt *at the balance point*, first decreases and then increases the current by altering the transfer resistance, probably at the cathode. An amount of current equal to ·14857 ampere, entering a surface of ⅛ths of a square inch, was found to be sufficiently strong to deposit nearly the whole of the silver from a solution at 60 deg. F. composed of 70·11 grains of free potassic cyanide, ·0297 grain of double cyanide, and three ounces of water, the liquid retaining dissolved a little less than that amount of silver at its balance point under those conditions. The strength of current *at the balance point* in a weak solution of potassic cyanide, varies inversely as the amount of silver salt added, and at about eight times the rate. A certain strength of current must enter a given surface of silver in a given liquid under stated conditions in order to prevent all corrosion and produce deposition. The addition of the double cyanide reduces the amount of current conveyed by the free potassic cyanide into the cathode *at the balance point*. Successive additions of double salt to a solution of potassic cyanide *not at the balance point*, first decreases and then increases the current by altering the transfer resistance; it alters the relation of the molecules of potassic cyanide to the cathode so as to diminish their power of transmitting current into

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that surface without depositing silver. The greater the proportion of double salt present, the greater the tendency to the deposition of silver. Addition of potassic cyanide to a week solution of the double salt *not at the balance point*, first decreases and then increases the current by altering the transfer resistance at the cathode; in this respect it behaves like addition of the double salt to a weak solution of potassic cyanide. With cathodes of platinum, a solution of potassic cyanide offered less resistance to the current (*not at the balance point*) than one of the double cyanide, but with silver cathodes the reversed effect occurred.

The balance point is a case of equalisation of molecular influences, including ordinary chemical corrosion, density of current, nature of cathode, temperature, proportions of water, argento potassic cyanide, free potassic cyanide, and the soluble salts present as impurities, either of which, by being disturbed, alters all the others. All these influences also have separate numerical values. A rise of temperature of 60 deg. F. requires an increase of ·000976 ampere to restore the equipoise. The experiments illustrate the dynamics of electro-silver plating; and the method employed in the research is applicable to the detection and measurement of molecular influence in electrolytes. In consequence of the alteration of any one of the conditions having the effect of altering all the remainder, all the above conclusions are limited in their application and are only correct under the conditions given in the paper. The fundamental explanation underlying these conclusions is, that the phenomena are essentially molecular; and that the mere presence and admixture of the double cyanide alters the molecular arrangement of the free cyanide *not at the balance point*, in such a way as to enable the latter to transmit a greater quantity of current into a cathode of given size, notwithstanding its being more diluted by the other salt.

The phenomena of the "balance point" constitute an interesting example of molecular equilibrium, in which the balance point may be compared to a ball suspended by an elastic cord, and having attached to it, a number of other similar cords, each drawing it in a different direction, and all of them being kept in a state of tension. In such a case an alteration of the degree of strain of any one of the cords, changes that of all others, and alters the position of the ball.

The research has a practical bearing both upon the measurement of electric currents by means of deposition of silver from a cyanide solution, and upon the technical process of electro plating. In the former it shows how a large proportion, or even the whole of a current may pass without being measured, and how the error may be reduced to the smallest amount; and in the latter, how a similar waste of current may occur, and how to prevent it.

It is manifest from the foregoing research, that the electrolytic balance of chemical corrosion of cathodes in other depositing solutions, such as those of gold, copper, nickel, &c., might form an extensive subject of experimental investigation.

Appended Note.- It was constantly found that in using a non-corrodible anode, such as platinum, the amount of current passing was very much more easily regulated by varying the size of the anode than that of the cathode. With a corrodible anode, however, such as silver, this effect was not observed.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY (LIMITED).

The nineteenth ordinary general meeting of the shareholders of this Company was held at the offices, Old Broad-street, on Tuesday last, under the presidency of Sir Daniel Gooch, Bart., M.P.

The SECRETARY (Mr. Edmund Dickens) read the notice convening the meeting and the minutes of the last meeting, which were approved by the present meeting and signed by the chairman as correct.

The report of the directors, an abstract of which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN, in moving the resolution that the report be received and adopted, said: I think I may congratulate you upon the continued success of our Company. The accounts will show you that during the past year a net profit of £92,260 has been made, and after paying interest on debentures, and also the interim dividend which was paid in the middle of the year, there is a balance available for dividend now of £130,245. The 15 per cent., which is now proposed to be paid to you, will absorb all that but £63,015, which is carried forward to next account. The work we have done in the past year is pretty clearly set forth in the report, but I will refer to it shortly. You see by paragraph A that 550 miles of cable have been laid under a concession from the Austrian Government between Corfu and Trieste, and it now forms part of the Eastern Company's system. The German Union Company's cable was repaired in the North Sea between Lowestoft and Greetseil. That cable was repaired in the winter, and was a matter that caused a great deal of trouble through the bad weather which prevailed. However, the cable was properly repaired, and is now in efficient working condition. Paragraph C refers to the laying of the German Union Company's cable, between Valentia, in Ireland, and Greetseil, in Germany. That amounted to 776 miles, and that cable was completed in April. The shore ends of the cable were laid in the previous year. 254 miles of cable were manufactured for the Western and Brazilian Telegraph Company, and laid in April between Ceara and Maranham, on the Brazilian coast. The Brazilian Submarine Telegraph Company's cable, off Pernambuco was also repaired, when the ship was out in that neighbourhood. Between the months of May and September extensive repairs were effected in the Anglo-American Telegraph Company's French Atlantic cable between Brest and St. Pierre, in depths up to 2,000 fathoms, after a submergence of thirteen years. I am sure it must be gratifying to the shareholders of this Company to find that a cable after thirteen years immersion was repaired. The cable itself was in perfect condition except in the parts where injury had taken place. Its repair has given confidence in cable property when it is seen that it may be raised after so many years. The "life" of a cable has been thought to be ten years; but I think we may safely say that we do not know what its life is if we can pick it up and repair it as we have done in this case. Great credit is due to the officers of the Company who were engaged in that work, for it was a very difficult one to perform. They were occupied some time in doing it, but their efforts were successful. In the month of August the Eastern Telegraph Company's cable between Porthcurnow and Lisbon was repaired in a depth of 2,700 fathoms, and a cable for the same company (234 miles in length) was manufactured and laid between Malta and Tripoli in October. As to the cable after being five years down, the pieces I have seen brought up are just as clean as when it was laid. During the month of October the Brazilian Submarine Telegraph Company's cable between Lisbon and Madeira was duplicated, 663 miles of cable having been manufactured for this purpose; and the Lisbon shore end of the original cable was relaid. A cable 965 miles in length has been manufactured for the Eastern Extension Telegraph Company, which will be laid in the China Sea between Hong Kong and Shanghai. The steamship "Scotia" is now engaged in that work, and is out there. The next paragraph in the report refers to the condition of the works, which are in an excellent state of repair and efficiency. The steamship "Calabria" was engaged by the Government as a troopship during the Egyptian war, and she is now on her road to Egypt again for the Government. The works we have in hand at present are about 900 miles of cable for the Eastern Company for the Red Sea, and the Great Northern cable for the China Sea of 1,280 miles. Those practically are the facts connected with the work we have done. As to the accounts, I do not think I can go through them in a useful way, but I should be very glad to answer any questions respecting them; or with regard to any other matter. I now move:—"That the report and accounts of the directors to the 31st December, 1882, submitted to this meeting, be, and the same are hereby received and adopted, and that a dividend of 36s. per share (in addition to the 12s. per share interest on interim dividend paid to June 30th, 1882) be paid upon all shares of the Company for the year ending December 31st, 1882, and that such dividend be paid free of income-tax."

Sir THOMAS FAIRBAIRN, Bart.: I have great pleasure in seconding that.

Mr. JOHN NEWTON said he was glad to hear the chairman give the weight of his high authority in telegraph matters in saying that the life of a cable was more than ten years. He had heard a contrary opinion expressed some time since by a person who was not so high an authority as Sir Daniel Gooch. It might now be taken as definite that the life of a cable was considerably more than ten years, if a cable laid down thirteen years ago could be brought from the bottom of the sea at a depth of 2,700 fathoms, the cable being found in sound condition. If that was the condition of a cable made and laid thirteen years ago he should like to know whether, as the cables that were manufactured now were of superior quality, there was not a greater probability that they would live longer even than those that were now thirteen years old, and were doing such good work. He thought that the holders of submarine cable property were sometimes doubtful as to their property being one that could be relied on; but the more that idea was dispelled the better for this Company and the other companies for which they worked.

The CHAIRMAN: There cannot be a doubt that the cables now made have all the experience of the last thirteen years, and we have every reason—we are certain, in fact, that those that are now made will last longer than those which were originally made. Where there is any risk of the teredo they are now protected by a coating of brass ribbon round the core, and the cables are all now protected by a composition which, we believe, will protect the hemp from decaying, and the salt water from getting to the iron wire. There is every reason to believe that cables now made will last longer than those which were originally manufactured. He then put the motion in the usual way, and it was carried unanimously. Continuing, he said: The next motion is the re-election of the directors, and I now move "That Lord Alfred Paget be and is hereby elected a director of the Company."

Mr. PHILIP RAWSON seconded the motion, which was carried unanimously.

The CHAIRMAN: I have now to move "That Mr. George William Campbell be re-elected a director of the Company."

Sir THOMAS FAIRBAIRN seconded the motion, which was carried.

The CHAIRMAN: The next motion is the election of the auditors, which is moved by the shareholders themselves.

Mr. GIBSON said that he had not the pleasure of knowing the auditors himself. He must, therefore, leave it to those around him, to whom probably those gentlemen were known. He then moved separately the re-election of Mr. John Gane and Mr. James Glegg at a remuneration of £150 each.

Both resolutions were carried.

The CHAIRMAN: That concludes the business of the general meeting. We now come to the business of the special meeting for the purpose of confirming the resolution you came to the other day. I will ask Mr. Burt to read it.

The SOLICITOR (Mr. Burt): The resolution which the chairman proposes is "That the following resolution, passed at the extraordinary general meeting of the Company held on the 6th February, 1883, namely: 'Resolved that the Bill now pending in Parliament, intituled "A Bill for removing doubts as to and for extending the powers of the Telegraph Construction and Maintenance Company (Limited), and for other purposes" be and is hereby approved subject to such additions, alterations, and variations, if any, as Parliament may think fit to make therein,' be and the same is hereby confirmed." It is needful by law that there should be two meetings, one to pass and the other to confirm the resolution, and the chairman now proposes that the resolution be confirmed.

Sir THOMAS FAIRBAIRN seconded the motion.

The CHAIRMAN put it to the meeting, and declared it carried, adding that that concluded the business of the meeting.

Mr. NEWTON moved a vote of thanks to the chairman, and expressed his regret at not hearing anything about the electric light business.

The CHAIRMAN: You should have come to the last meeting.

Mr. NEWTON replied that he thought the first was a formal meeting, and, therefore, he did not attend. He thought that the present would be the more important meeting. There had been great excitement about electric lighting, but he did not suppose in their property they would see, as had been seen in other cases, their shares, say, at 400 per cent. premium, and then 50 per cent. discount. He was very glad to see their shares had been very little affected by the proposal of the directors of the Company to engage in electric lighting business. They had done their work so well as sub-

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marine cable makers that no one else, he said, could touch them. If they were going to have something of the same sort with regard to electric business, then their shares must go up. He would, however, like to know if the shareholders would have an opportunity of inspecting it at the Crystal Palace or anywhere else, so that they might see something of the character of the light which was under the control of the Company.

A SHAREHOLDER seconded the motion.

The CHAIRMAN: I did not explain more in detail the Bill before Parliament, because I thought it was fully explained at the last meeting. The object of that Bill is to obtain powers which we have not got now, that is, powers to use electricity in every direction for which electricity is available. Our present power is limited to telegraphy, and we are seeking powers to carry out electric lighting arrangements in the same way with the appliances we have got, which we believe we can do to the interests of the shareholders. As to exactly what we are going to do, I think you must wait till we get the Bill. I think we shall get a fair share of electric lighting business throughout the country, but until we get the power we cannot say what we can do. I hope we shall be as successful as we have been in the past, and we shall do our best.

The meeting then separated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES FEB. 28.		BUSINESS DONE WEEK ENDING FEB. 28. Highest.	Lowest.
Anglo-American	50,	51	50	49½
Do. Preferred	81,	82	81½	81
Do. Deferred	18½,	19	18¾	18
Brazil Submarine	12½,	12¾	12 9-16	12⅛
Cuba	9½,	10½	--	—
Do. Preference	16½,	17½	—	—
Direct Spanish	6,	6½	—	—
Do. Preference	16,	17	16½	16½
Direct United States Cable	12½,	12½	12 7-16	12⅛
Eastern Telegraph	10¾,	11⅛	11 1-16	10⅞
Do. 6 per Cent. Preference	13,	13½	13½	13½
Do. 5 per Cent. Debentures, 1899	103,	106	104	104
Eastern Extension	11¼,	11⅜	11⅜	11 11-16
German Union	10½,	11	10⅞	10⅞
Globe Telegraph and Trust Company	6¼,	6½	6 13-16	6 11-16
Do. Preference	12½,	12⅝	12⅞	12⅝
Great Northern	12,	12¼	12⅜	12⅜
Indo-European	32,	33	—	—
Mediterranean Extension	1⅛,	2⅛	—	—
Do. Preference	7,	8	7½	7½
Reuter's	10½,	10⅝	10⅝	10½
Submarine	260,	265	—	—
West India and Panama	1½,	1⅝	1⅝	1 5-16
Do. 1st Preference	7,	7½	—	—
Western Brazilian	7⅞,	8	8	7⅞
West. Union 7 per Cent. 1st Mortgage	122,	126	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	105	105

TELEPHONES.

Consol. Telephone and Maintenance	⅝,	¾	13-16	11-16
Oriental	⅝,	¾	⅝	11-16
United Telephone	11½,	12	11 11-16	11½

ELECTRIC LIGHT.

Anglo-American Brush Light (£4 pd.)	4⅛,	4¼	4¼	3⅞
Do. (fully paid)	7⅛,	8⅛	7¾	6
Hammond Light	3⅛,	3¾	3 9-16	3⅜
Eastern Electric (£5 paid)	1⅛,	1⅞	—	—
Pilsen, Joel, and General Electric	⅛,	1	⅝	11-16
Swan	1⅛,	2⅛	2⅛	2
Maxim-Weston	¼,	⅜	7-16	5-16

TRAFFIC RECEIPTS FOR JANUARY, 1883.

COMPANIES.	Jan., 1883.	Jan., 1882.	Increase.	Decrse
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	2,800	3,021	—	221
Direct Spanish Telegraph Company	1,689	2,055	—	366
Direct United States Cable Company	—	—	—	—
Eastern Extension Telegraph Company	32,822	33,129	—	307
Eastern Telegraph Company	—	—	—	—
Great Northern Telegraph Company	18,240	17,110	1,130	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

TO THE SHAREHOLDERS OF THE

UNITED TELEPHONE COMPANY (Limited).

36, Coleman-street, London, E.C., 28th February, 1883.

Dear Sir,—The Board of Directors, in their circular of the 24th of May last, gave to the shareholders a short history of the result of the litigation which had taken place up to that date on the Company's Patents. In Scotland the Company had obtained judgment in its favour, both on Edison's Patent for the Carbon Transmitter and on Bell's Patent for the Magneto Telephone. In England a similar decision had been obtained in favour of the Company under Bell's Patent, but a technical objection to the validity of Edison's Patent had been upheld by Mr. Justice Fry, and under these circumstances, although the Hunning's Transmitter manufactured and sold by the defendants was held to be within Edison's specification, an injunction was refused.

The Directors, on a careful consideration of the circumstances of the case, came to the conclusion that an immediate application for a "disclaimer" was desirable. Although they had good reason to hope that Mr. Justice Fry's decision on this technical point would not be sustained by the Court of Appeal, they did not forget that during the whole time the appeal was pending an adverse decision would be standing against them, and that during that time they would be unable to restrain the manufacture and sale of infringing instruments; whereas an application for a disclaimer, if promptly made, would be heard before the long vacation, and, the blot upon the patent once cured, Mr. Justice Fry's decision would stand in all points in favour of the Company. The necessary petition for leave to "disclaim" was therefore at once lodged, and on the 29th of July the application was granted by the Attorney-General, and the necessary "disclaimer" was filed on the 16th of August.

By the terms of the Attorney-General's fiat protection was given to transmitters manufactured prior to the 29th of July by certain persons who opposed the application, but the number of instruments so protected is not large. Protection was also given to contracts bonâ fide entered into by the opponents for the manufacture of transmitters before the 29th of July, and under this proviso an attempt is being made to claim protection for a large number of instruments for the manufacture of which verbal contracts are stated to have been made. The Directors question the bonâ fides of these alleged contracts, and they have taken the necessary steps to have the point determined by the Attorney-General.

The disclaimer having been filed, the Directors withdrew their appeal from Mr. Justice Fry's decision. Upon the patent as disclaimed the decision was entirely in the Company's favour, and no reason, therefore, existed for bringing it under the review of the Court of Appeal. Proceedings have since been taken under the patent as amended against several persons infringing the patent, and in every case the defendants have submitted to judgment and paid the costs of the proceedings.

Messrs. Harrison, Cox-Walker, and Co., against whom an injunction was granted for infringement of the Bell Patent in May last, lodged an appeal against this decision, which came on for hearing on the 28th of January last, before the Master of the Rolls, Lord Justice Lindley, and Lord Justice Bowen. After a most patient hearing, extending over nine days (nearly seven of which were occupied by the appellants), the court gave an unanimous decision in favour of the Company, upholding Mr. Justice Fry's decision, and dismissing the appeal with costs.

There remains, of course, the possibility of an appeal to the House of Lords, but, even should such an appeal be made, the Directors feel great confidence that a patent which has been unsuccessfully attacked on three different occasions, which has been under consideration by the courts for thirty-three days, and which has been supported by the decisions of two judges of first instance and of three judges of appeal, is not likely to be broken down if brought before the ultimate Court of Appeal.

The Company has obtained injunctions against the following persons and firms for infringing one or more of its patents:—

Alexander Maclean of Edinburgh.	Cox and Williamson of Plymouth.
M. Theiler and Sons of London.	Edwin Butler of Liverpool.
Harrison, Cox-Walker, and Co., of Darlington.	W. Haines of Birmingham.
Orme and Co. of London.	F. Hebden and Co. of Bradford.
	H. and E. J. Dale of London.

In other cases apologies have been accepted, accompanied by undertakings to discontinue the manufacture or sale of infringing instruments.

The Directors, while congratulating the shareholders upon the successful manner in which their patents have been upheld both in England and Scotland, think the present a favourable opportunity to give a few figures illustrative of the progress of the Company.

The number of exchange subscribers to the London system was:—On 28th of February, 1881, 845; on 28th of February, 1882, 1,505; on 28th of February, 1883, 2,541; showing an increase of 660 subscribers for the year between February 28th, 1881, and February 28th, 1882, and of 1,036 subscribers for the corresponding period between 1882 and 1883.

The gross income from London rentals alone has now reached £60,000 per annum, and the annual value of the unexecuted orders in hand—which will be added day by day to the revenue of the Company as the lines are completed—is to-day about £5,000. The Company is receiving on an average orders each day of the annual value of about £100.

As showing the use made of the Company's exchange system in London, the calls of the subscribers on five days in the third week in February (omitting Saturdays and Sundays) for the past three years were as under:—

1881	Feb. 15..... 4,195 calls Feb. 16..... 3,986 calls Feb. 17..... 4,361 calls Feb. 18..... 4,838 calls Feb. 21..... 4,576 calls	Total for the five days ..... 22,256 being a daily average of ... 4,451 or 5·13 per subscriber.
1882	Feb. 15..... 9,576 calls Feb. 16..... 9,770 calls Feb. 17..... 9,662 calls Feb. 20..... 9,790 calls Feb. 21..... 9,788 calls	Total for the five days ..... 48,586 being a daily average of ... 9,717 or 6·57 per subscriber.
1883	Feb. 15..... 19,089 calls Feb. 16..... 20,042 calls Feb. 19..... 18,874 calls Feb. 20..... 18,501 calls Feb. 21..... 18,602 calls	Total for the five days ..... 95,108 being a daily average of ... 19,021 or 7·59 per subscriber.

Each call implies an answer, and consequently the number of calls doubled will represent the minimum number of messages daily transmitted along the Company's wires.

The Directors are availing themselves of every opportunity of extending their business in the provinces by enlisting local interest in the formation of subsidiary companies—one for the western counties and another for the South of England and Brighton being in course of formation—in addition to those already established, in which, as the shareholders are aware, the Company has now so large and progressive an interest, both in shares and royalties.

In conclusion, the Directors would urge each shareholder to supplement the exertions of the board by using his personal influence among his friends to bring subscribers to the Company's system.—Yours faithfully,

JAMES BRAND, Chairman.

INSULATED ELECTRICAL WIRE, Silk, Cotton, or India-rubber covered. Conductivity guaranteed. German Silver Wires for Resistance. Braided Handle Cord, Silk Cord for Electric Bells, &c.—WILLIAM RICKARD, Derby London Agent (stock kept), EDWIN HOLLOWAY, 2, Gutter-lane, E.C.

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RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

2823. GENERATING AND STORING ELECTRIC ENERGY, &c., *C. Westphal, Berlin.*—*15th June*, 1882. 8*d*.

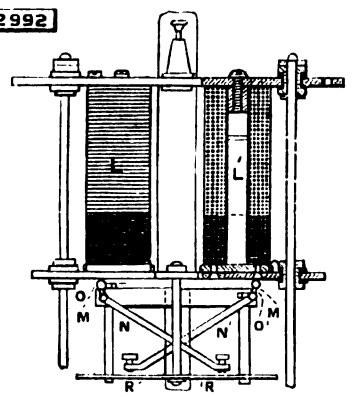
The object of this invention is to produce electric currents from the gaseous compounds of coal, and so avoid the roundabout method of producing them by means of a steam engine and dynamo machine. The principle of the invention consists in producing a constant current of electricity by means of water gas or generator gas and oxygen—that is to say, by using these gases for artificially producing on plates the state assumed by electrodes during the electrolytical decomposition of water, which state is the cause of the production of polarisation currents. The patent describes the apparatus employed by the inventor to accomplish his object.

3010. IMPROVEMENTS IN ELECTRIC LAMPS WITH INCANDESCENT CONDUCTORS, *W. E. Debenham, London.*—*26th June*, 1882. 4*d*.

To obviate the evil caused by the unequal expansion of the glass and platinum conductors of incandescent lamps, the inventor takes two samples of glass, one having a higher the other a lower coefficiency of expansion than the platinum, and mixes these two samples together, to render the resultant as near as possible of the same coefficiency of expansion as the platinum. The carbons he makes of sewing cotton soaked in a solution of gluten dissolved in alcohol. Other improvements are described.

2992. REGULATING THE ACTION OF ELECTRIC ARC LAMPS, *W. R. Lake, London.*—*23rd June*, 1882.—(*A communication from J. M. A. Gérard Lescuyer, Paris.*) 8*d*.

The illustration shows the method of regulation adopted. The action of the apparatus is as follows:—The carbons being in contact, the current circulates around cores L L^1, and draws them up. In rising they lift cross-bar M, which by means of small links O O^1 causes the pieces N N^1 to clamp the upper carbon holder and lift it, thus striking the arc. When the length and resistance of the arc increase more of the current begins to travere the fine wire coil at the bottom of the electro-magnet, and this flows in a reverse direction to that through the thick or upper coil. Consequently, L L^1 are demagnetised, and N N^1 descend until they come into contact with disc R, when they release the carbon holder.

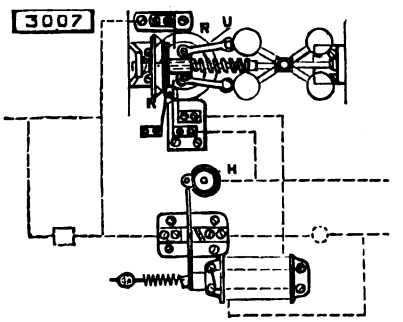


2990. APPARATUS OR MACHINERY FOR GENERATING, CONTROLLING, AND UTILISING ELECTRIC CURRENTS, *J. H. Johnson, Lincoln's Inn-fields.*—*23rd June*, 1882.—(*A communication from La Compagnie Electrique, Paris.*) 6*d*.

This relates, first, to improvements in dynamo machines, having Gramme ring armatures and electro-magnets provided with multiple armatures which completely surround the apparatus, so as to render them fit for use as generators and motors for the transmission of power; secondly, to the regulation of the speed of the motors in this respect. The inventor claims "the combination of electric generators of feeble residual magnetism sending a current to motors possessing great residual magnetism, and their application to electrical purposes as described."

3007. MACHINERY FOR THE REGULATION OF SPEED IN MACHINERY DRIVEN BY ELECTRICITY, &c., *Fleeming Jenkin, Edinburgh.*—*24th June*, 1883. 6*d*.

The invention is illustrated in the accompanying engraving, which represents an arrangement of governor and governing relay. Suppose the speed of the machine to which the current is being transmitted exceeds the limit, spring V has been so adjusted that slider U will bring springs 2 and 3 into contact, pressing them together by spring 1, which is insulated from the other two. Spring



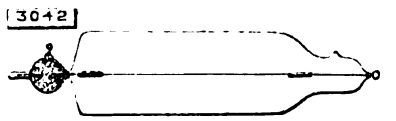
2 is connected by wire with terminal H, and therefore a current instantly traverses the other wires exciting the core of electro-magnet. The resistance of the electro-magnet coils is such that only a suitable portion of the main current is diverted through the magnet. The armature and lever are instantly pulled over, breaking the current through the machine and making contact. Part of the current is now flowing through to the frame, and part through the resistance coil to frame. If the speed of the machine should be such as to bring the slider of the governor into contact with spring 4, the circuit of the receiver will be closed.

3108. SECONDARY BATTERIES OR MAGAZINES OF ELECTRICITY, &c., *H. J. Haddan, Kensington.*—*1st July*, 1882.—(*A communication from C. F. Brush, Cleveland, Ohio, U.S.*) 2*s*. 4*d*.

To form the plates the inventor takes two ordinary lead plates in dilute sulphuric acid, and charges them in such a manner that a coating of peroxide of lead of sufficient thickness is formed on both of them; these plates are then associated together in the usual manner, and charged so that one of the plates remains uncharged, and constitutes the oxygen element of the battery, while the other has its charge reversed, and constitutes the hydrogen element. According to another part of this invention, the plates before the process of forming are coated electrolytically with a deposit of coherent lead. With grooved plates the inventor employs special means to make the deposit of coherent lead thick in the grooves. Another part relates to the covering of plates with porous metal, reduced from oxides by reducing gases. Another part relates to the construction of plates of masses of finely-pulverised metallic lead and lead oxide in an intimately mixed condition, pressed hydraulically together into a compact mass. Other methods of forming plates are also described, as well as methods for charging batteries.

3042. INCANDESCENT ELECTRIC LAMPS, *F. L. Willard, London.*—*28th June*, 1882. 6*d*.

The invention relates to a method of avoiding fracture of the filaments of incandescent lamps through being rigidly connected to the leading-in wires, and so allow for a certain amount of con-



traction and expansion. To accomplish this the inventor inserts the platinum wires into the two ends of a cylindrical glass bulb, as shown in the figure, in which he places the filament. This bulb has at its base a small bulb containing mercury. The filament is made from a species of veneer called "white lines," carbonised. One end of it is cemented with a mixture of coal-tar and coke-dust to one leading-in wire, and the other end to another piece of platinum wire which dips into the mercury, the other leading-in wire being fused into the small end of the bulb and in contact with the mercury.

3047. TELEPHONIC RECEIVERS, *W. Spence, Chancery-lane.*—*28th June*, 1882.—(*A communication from M. Kotyra, Paris.*) 6*d*.

The chief peculiarity in this invention is the construction of the compound magnet and the soft iron armature. The magnets are composed of multiple bars separately magnetised and solidly bound together. The polar extremities carry the soft iron cases of the bobbins, and the whole forms a magnet which is a sort of interrupted frame.

3101. AN IMPROVED ARC ELECTRIC LAMP, *R. H. Courtenay, Southampton-buildings.*—*30th June*, 1882. 6*d*.

This relates to a peculiar gripping arrangement for regulating the carbons. One or more solenoids are so arranged that each shall draw up cores, which lift a small slotted plate, the sides of the slots being of a taper or wedge shape. In each of the slots are placed movable blocks, which grip the upper carbon when the current energises the solenoids, thus lifting the rod and striking the arc. The blocks are retained in position by springs.

3036. DYNAMO-ELECTRIC MACHINES, *W. E. Ayrton, F.R.S., and J. Perry, Finsbury.*—*27th June*, 1882. 6*d*.

The first part of the invention consists in the use of field magnets made of steel and iron combined; either a steel tube enclosing an iron core, or *vice versâ*, or alternate plates of the two metals. The inventors find that with this arrangement a dynamo will behave like a combination magneto and dynamo machine, and that great constancy is the result. The second part relates to the winding of any ring armature. The ring is made of two pieces joined together, so that the screws are flush with the ordinary surfaces of the ring. The coils are slipped on these halves, and between every two is also slipped a ring of wrought iron, out of which a small portion is cut at one place, so that the ring is incomplete, as shown in the

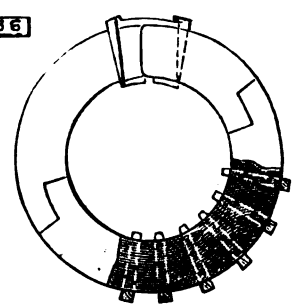


figure. This is to prevent induction currents. Other parts of the invention relate to a method of connecting up when any even number of pairs of field magnets are used near the armature, and to the use of an armature core of phosphor bronze, or brass, or steel, with a great many rivets of soft iron passing through it.

3128. ELECTRIC LOGS OR APPARATUS FOR ASCERTAINING THE SPEED OF SHIPS, &c., *R. M. Lowne, Finchley.*—*3rd July*, 1882. 6*d*.

The inventor employs a rotator similar to an ordinary mechanical ship's log, the cable attached to which contains two insulated wires, which are connected respectively to a recording apparatus on the ship and to the rotator under water. The rotator is made to make and break an electrical circuit at every given number of revolutions so as to operate the recording apparatus on board ship, and thereby record the number of revolutions of the rotator. The inventor claims the machinery required to carry out the invention, and also novel methods of establishing connection between the battery poles and the rotator.

3231. ELECTRICAL CONDUCTORS, *F. Jacob, Westminster.*—*11th July*, 1882. 6*d*.

This relates to Patent No. 231 (17th Jan., 1882), granted to C. W. Siemens, and communicated to him by the present inventor. That patent related to "improvements in telephonic conductors" only, and the object of this patent is to claim the invention there described as applied to electric conductors generally, whether employed for telegraph, electric light, or other purposes. The invention consists in a method of connecting several sets of electrical instruments by employing the double conductors of one set as a single conductor for another set, and multiples of such double lines as single lines.

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SLIP

PARA.—The cable between Maranham and Para is now repaired.

THE CHANNEL ISLANDS.—Telegraphic communication between Guernsey and Alderney is again restored.

POSTMASTER-GENERAL.—Mr. Fawcett has resumed his official duties, and was present in the House of Commons on Monday last.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 2nd inst. amounted to £4,406.

POST OFFICE TELEGRAPHS.—Mr. B. Murphy, sorting clerk and telegraphist at Londonderry, has been appointed postmaster of Curragh Camp.

SIGNS OF THE TIMES.—"Electric light fittings are also becoming an important staple with one or two leading firms."—*Times'* Birmingham Trade Report.

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated earnings of this company for February were £1,544, against £2,109 in the corresponding period of last year.

BOOKS RECEIVED.—"Sopra un modo d'Interpretare i Fenomeni Elettrostatici Saggio Sulla Teoria del Potenziale." di G. B. Ermacora. (Padova: A. Draghi, publisher. 1882.)

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February, 1883, amounted to £46,667, and to £44,046 in the corresponding period of 1882.

ELECTRIC LIGHTING FOR BEDFORD.—The Bedford Local Authority have applied to the Board of Trade for a license to supply electricity for public and private purposes in the borough.

ELECTRICAL TRANSMISSION OF POWER.—On Thursday next, Dr. C. W. Siemens, F.R.S., will lecture at the Institution of Civil Engineers, on "The Electrical Transmission and Storage of Power."

NATIONAL TELEPHONE COMPANY.—At a meeting of the directors of this company, held on the 1st March, it was resolved to pay 6 per cent. preference dividend for the six months ending 31st December last, less income-tax.

EASTERN EXTENSION AND CHINA TELEGRAPH COMPANY.—The traffic receipts of this company for the month of February, 1883, amounted to £29,391, and to £27,473 for the corresponding period of 1882, being an increase of £1,918.

SAFETY LAMP FOR MINERS.—It is stated that hundreds of communications have been received by Mr. Burt, M.P., on the subject of an electric miners' safety lamp, for which £500 has been offered by Mr. Lever, as announced recently in our columns.

THE AUSTRALIAN CABLES.—Communication with Australia was interrupted on Tuesday by the breaking of both Port Darwin cables. Both lines were, however, repaired by Wednesday afternoon. The break occurred about 100 miles from Banjoewanjie.

MESSRS. DENNIS AND CO.—We are informed that Messrs. W. F. Dennis and Co., of 101, Leadenhall-street, E.C., sole agents for Messrs. Felten and Guilleaume, wire drawers, &c., of Mülheim-on-Rhine, have opened a branch office at 3, Tower-chambers, Water-street, Liverpool.

DUPLICATION OF THE HONG KONG-SHANGHAI CABLE.—The laying of the duplicate cable from Hong Kong to Shanghai will probably be completed this week. It has been manufactured by the Telegraph Construction and Maintenance Company for the Eastern Extension Telegraph Company.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company for February, 1883, were £17,800. For the period from 1st January to 28th February, 1883, they were £36,040, against £34,360 for the corresponding months of 1882, and £34,408 for the same period of 1881.

ELECTRIC LIGHTING IN THEATRES.—Mr. J. E. Jackson, manager of the Electric Carbon, Storage, &c., Company, Leith, has received instructions to light up the Theatre Royal, Edinburgh, throughout. Accumulators will be used to a great extent. This is the third theatre the company has lighted.

ROYAL SOCIETY.—The paper which was to be read before this Society on Thursday last was entitled "Notes on the Absorption of Ultra-Violet Rays by Various Substances. Notes on the Reversal of Hydrogen Lines; and on the Outburst of Hydrogen Lines when Water is Dropped into the Arc. Note on the Order of Reversibility of the Lithium Lines." By Professors Liveing and Dewar.

THE EDISON SYSTEM IN SCOTLAND.—On the evening of Friday, March the 2nd, the Scottish branch of the Edison Electric Light Company gave an exhibition of their system in the rooms which they have just opened at 104, West George-street, Glasgow, with Mr. C. T. Grant as manager. One of the principal features of the exhibition was a three-hundred candle lamp, which was only two feet six inches high and fifteen inches in diameter.

A LAMP FOR COLLIERIES.—M. G. Mangin has invented a miners' lamp, in which a Swan incandescent lamp, supplied by a Faure accumulator, is enclosed in a casing of water, which serves for two purposes. It increases the illuminating power; and, if the lamp should break, the incandescent carbon would be at once extinguished. The glass casing, with the conductors covered with lead, is, in turn, enclosed in a copper case, silvered inside, and provided with strong converging sides, which throw a bright light.

ACCIDENT TO A TELEGRAPH STEAMER.—As the new steamer, "Viking," built by Messrs. Pearce Brothers for the Western and Brazilian Telegraph Company, London, was entering the tidal harbour at Dundee, on Friday, the 2nd instant, the weather at the time being foggy, she ran up against the west quay head, doing considerable damage to the woodwork below water mark. The steamer's stem was much twisted, and it is expected that she will require to be docked before any real estimate of the damage can be ascertained.

TENDERS WANTED FOR A TELEGRAPH LINE.—As no satisfactory tenders have been received for the erection of a telegraph line in the Orange Free State, South Africa, fresh tenders have been invited by the Government of that State. These tenders are to be sent in by the 5th May next. The length of line will probably amount to 286 miles. Specifications can be seen at the offices of the different Free State Consuls in London; also at Berlin and Hamburg, in Germany; at Arnhem, in Holland; at Brussels, in Belgium; and at Paris.

THE EASTERN EXTENSION COMPANY'S SYSTEM.—We understand that an important link in this system is shortly to be carried out by arrangement between the Siamese Government and the Eastern Extension Company. The extension will consist partly of cable and partly of land line, and when complete will form a duplicate route from China, &c., to Singapore. The new route will consist of a cable from Penang to Quedah, then a land line across the Malay peninsula to Singora, on the Gulf of Siam. From Singora a cable

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will be laid across the Gulf to Bangkok. The French will connect Bangkok with Saigon by a land line across the Cambojian peninsula, thus completing the link.

THE RATING OF TELEGRAPH WIRES.—A question of some interest to telegraph companies was discussed at a recent meeting of the Helston Board of Guardians. This was the rating of telegraph wires. It appears that the Direct Spanish Telegraph Company have a few miles of underground wire running through this part of Cornwall, and that hitherto the overseers have neglected to rate the company for their line. The gentleman on the board representing the assessment committee stated that this neglect arose from the fact that the committee were awaiting the issue of an appeal against the rating of wires, in order to act in accordance with the decision, and to be able to fix on some definite assessable value. Another member stated that the present company did not object to the rate being made, but to the amount. Eventually it was agreed between the company's representative and the board that £2 per mile would be a fair sum.

COMMUNICATION WITH LIGHTHOUSES.—In the House of Commons on Friday week, in answer to Mr. Vivian, who wanted to know whether "there was any immediate prospect of the Trinity Board taking into their favourable consideration the question of establishing communication between outlying lighthouses and the shore by means of electric cables," Mr. Chamberlain stated that "This subject had received for a long time the attention of the Trinity Board and of the Board of Trade. He was not quite certain that the results to be obtained by such a communication as was suggested would justify the very large expenditure which would have to be incurred. At the same time, he was anxious that the experiment should be made. He had learnt some time ago that the Telegraph Construction and Maintenance Company were willing to try an experiment for twelve months at their own risk and cost. He had sanctioned the experiment with the proviso that, if successful, the Trinity House would be allowed to purchase the cable and apparatus for £3,730. He thought it best, however, that the determination of the undertaking should be left to Sir James Douglas, the engineer of the Trinity House Corporation. The Telegraph Company had rejected that condition, so that for the moment the negotiations had come to an end."

BICHROMATE BATTERIES.—M. Luigi Ponci, director of the Technical Institute at Coma, thus describes a new bichromate battery made by him. It is composed of one kilogram of bichromate of potash, four litres of water, and two litres of chlorhydric acid. The bichromate is crushed and dissolved in boiling water. After being completely dissolved, the whole of the acid is added to it. In this way a liquid is obtained containing a mixture of chloride of potassium and bichromate of potash. The use of this liquid prevents the formation of crystals in the battery. The battery is contained in a wooden case, lined inside with lead, and holding six glass jars of rectangular form, the bottoms of which are pierced. These jars rest in the case on sheets of glass, which allow the liquid to circulate. The case is furnished with a leaden syphon tube, with which the battery can be charged and discharged. The elements are composed of a sheet of zinc and two plates of carbon. The two poles thus obtained are insulated from one another by a small band of india rubber, and compressed into a solid block. A case of six cells will give a current of the same intensity as six Bunsen cells, small size, for two hours. With three cases an Edison eight candle lamp of small resistance can be kept alight, and with eight cases a good arc light can be maintained.

"THE ELECTRICIAN" SUPPLEMENT, No. 2.—With our last issue we published No. 2 of our series of proposed supplements. It consisted of a table, giving the relation between the resistance and weight of electric lighting leads of various diameters—single wire, 7-strand, and 19-strand—with the amount of current which can be safely carried thereby, and other data. Owing to an oversight, the heading of the second column from the right hand side of the table was printed "Per minute," instead of "Per 100 yards." The mistake is so obvious, that, doubtless, many of our readers have already made the necessary correction. Also, for the conductivity given in footnote (*a*) read $R = \frac{\cdot 003265}{d^2}$ instead of $\frac{1003265}{d^2}$. We have received many kindly criticisms, some of which we publish in our correspondence, and, judging from the tone of the letters, we hope that we have succeeded in supplying something that will be of practical utility. It must be remembered, however, that any figures relating to electric light leads must necessarily be purely tentative, having regard to the present position of the industry they relate to. As time goes on, however, "tentative" will give place to "perfected," and we shall not be slow to make our readers acquainted with the fact. In the meantime we shall be glad of suggestions and criticisms, which will receive due consideration at our hands. Supplement No. 3 is in course of preparation, and we hope that its publication will not be so long delayed as was that of Supplement No. 2. We may add that the latter will not at present be issued apart from the number of *The Electrician* containing it, as we hope that further information and criticism may enable us to greatly improve the table.

PNEUMATIC TUBES AND ELECTRICITY.—A good illustration of how time can be saved by the aid of pneumatic tubes and electricity is afforded by the following extract from a recent issue of the *Northern Echo*, of Darlington:—"The telegraphic messages received daily in Darlington Post Office from all parts of the world have, for some time past, been delivered to the *Northern Echo* office direct by means of a pneumatic tube. This apparatus has dispensed with the necessity of telegraph boys travelling to and fro at all hours of the night between the telegraph and *Echo* offices. Messrs. Cox-Walker and Co., of Darlington, the eminent telegraph engineers, have now completed a most important improvement in this clever and ingenious apparatus, of which they were the original constructors. Heretofore telegraphic signals have been exchanged between the Post Office and the sub-editor's room, announcing the despatch and arrival of messages. To work the signals it was necessary for an operator at either end to touch a spring button, setting the electric current in motion. By the alteration now brought into working order this necessity is dispensed with. Messages are sent through the tube without preliminary notice immediately on their arrival, and, by a new automatic arrangement, each message, on its arrival in the *Echo* office, reports back to the Post Office by telegraph its own delivery. In less than twelve seconds about three times as much written matter as is contained in this paragraph is conveyed from the telegraphist to the sub-editor, and the fact of its safe delivery acknowledged back in the Post Office."

POST OFFICE CIRCUMLOCUTION.—Under this head, Mr. Henry Chapman, of 113, Victoria-street, S.W., writes to the *Standard* of the 2nd inst. as follows:—"On the night of

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Tuesday, the 18th July last, I received from the Post Office what purported to be a telegram from Spain, but, on opening it, I found that the message had been entirely left out, and the name of the sender—itself misspelt—alone appeared on the form. Early on the following morning (Wednesday) I applied at the Post Office for an explanation, and was told that the only way to find out if there was any mistake was to have the message repeated; but to do this I should have to make a deposit of eight shillings and sixpence, which would be immediately refunded if it were found that an error had been made in transmission. I paid the deposit, and waited in vain all day for the repetition of the telegram. During the morning of the next day, however (Thursday), it was brought to me, not quite correct yet, but still intelligible, as this time it contained the message itself. I thereupon wrote to the Secretary of the General Post Office, stating the case to him, and received a reply that the matter was being looked into. Not hearing further I wrote to him again on the 25th August, asking to have the eight shillings and sixpence refunded, and received a reply, dated 30th August, stating that the matter was still being investigated. On October the 19th I again wrote to the secretary, recapitulating the facts, and asking for the deposit to be refunded, and on the 24th October I received a similar letter to the previous one. On November 30th I again asked to have the eight shillings and sixpence returned, and received a reply that 'the matter shall receive attention.' On December 9th I again wrote and got a similar answer, and, being apparently no nearer to a solution than when I wrote the first letter, I wrote again to the secretary on the 13th ultimo, and have received the following answer:—'In reply to your letter of the 13th instant, I beg leave to inform you that it is the practice of the department to retain the forms of European foreign telegrams for no longer period than six months, and the telegram to which you refer having been handed in more than six months ago, I am unable to comply with your request.'"

Induction Coils, Portable Batteries, and Electric Lights.—This was the title of a recent paper read by Mr. Charles J. Clark before the Glasgow Philosophical Society. He began by describing an apparatus he had invented for lighting gas by means of electricity. He then proceeded to show how, in the course of his investigations, he had discovered that by the use of iron wire interlaid with cotton he had succeeded in producing a perfect induction coil greatly less in size and at little more than half the cost of the coil formerly in use. He next showed how by using a similar coil a small portable battery had been constructed which could be utilised for many practical purposes, as, for example, in the ringing of bells, or the production of lights from small incandescent lamps. In illustration of the latter use, a gentleman by whom the author of the paper was accompanied showed an electric light burning in his scarf-pin, the electricity being supplied from a small battery carried in his waistcoat pocket. At the close of the paper Sir Wm. Thomson paid a high compliment to Mr. Clark for the industry and perseverance he had shown in perfecting his valuable inventions. The improvements he had made in portable batteries were of the greatest importance. He himself had been experimenting for years in the same direction with exceedingly little result, and he had often wished for a small portable battery such as he now saw realised. Setting aside such applications of the incandescent lamp as the placing of it in a gentleman's shirt pin or in the hair and dresses of ladies for the amusement of the public, as by the fairies in *Iolanthe*, Mr. Clark had shown how it could be turned to important practical uses. A railway traveller might, for example, have a lamp which would burn for an hour, which was as long as any one should read in such circumstances, and it would also be useful during the night or in the sick room, rendering unnecessary the objectionable practice of keeping gas on the peep or of striking lucifer matches. In reply to a question, Mr. Clark said he understood that some explosions had taken place with the gas lighter at the works of Mr. Crum, of Thornliebank. He had since, however, made such modifications in the apparatus as would render explosions in future impossible.—Mr. Thomas Gray next read a paper on a new seismographic apparatus, to be used at Tokio, Japan, in recording the time of occurrence of and the horizontal and vertical motion during an earthquake.

Electric Lighting for Warkworth Harbour.—We take the following from the *Newcastle Daily Chronicle*:—"In several of the principal engineering establishments on the banks of the Tyne electric lighting has come into use, and seems to give much satisfaction to both workmen and employers. There is, however, no use to which it can be more suitably put than the illumination of wharves, jetties, and coaling staithes, on account of the extent of its range. An example of this use of the electric light may be seen at the Lambton Drops, and Mr. Andrews, the owner of Warkworth Harbour, has decided to repeat the experiment. Indeed, so prosperous, comparatively speaking, has Warkworth Harbour become, that it has of late been felt that increased facilities for the shipment of coal at night should be provided. Amble, on the south side of the harbour, is the focus of a number of important collieries which ship a large quantity of coal annually. Shipments at night have been carried on under such disadvantages, owing to defective light, that it was determined to illuminate the quays and staithes on the Amble side of the harbour by electricity. Two companies, the Hammond Brush Lighting Company and the Jablochkoff Electric Light and Power Company (Limited) tendered for supplying the necessary apparatus. Mr. Andrews, in order to judge of the qualities of the two lights, arranged with the two firms to compete for the contract. The rival companies proceeded to fix up apparatus and lamps capable of lighting up the shipping berths, the staithes, and lines of railway running down to the quay. A well-adapted engine house has been erected near the quay, and in it has been placed a Tangye engine of about 12 horse-power, with cylinders 8in. diameter by 16in. stroke. This engine is of special design for driving electrical machines, and was exhibited at the Tynemouth Exhibition. It makes one hundred revolutions in the minute, and has been erected with special attention to steadiness. The Hammond Brush Lighting Company have put up six lamps, and the Jablochkoff Company ten lamps, each connected with a Gramme dynamo machine. Both lights were put to a test the other night, each being used a quarter of an hour, and then their combined illuminating power was tested. The result in each case appeared to be very satisfactory, and we would not venture to give an opinion as to the relative merits of the two lights. The result of the competition will not be arrived at until a month's trial, but whichever light is used it will, we believe, be found to be much better adapted to the lighting of coaling staithes than gas."

Telegraph Clerks' Grievances.—A large and enthusiastic meeting of Edinburgh telegraph clerks was held in the Ship Hotel on Saturday last, for the purpose of con-

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sidering how far the Postmaster-General's recent scheme of revision had ameliorated the general condition of the service. The utmost unanimity of opinion was expressed regarding the failure of the scheme to adjust many pressing grievances that had been embodied in the united petition of 1881. The concessions already granted by Mr. Fawcett were gratefully acknwledged by those benefited, but it was pointed out that the great bulk of the staff, as was the case throughout the service, had received little or no benefit from the application of the scheme. Special attention was drawn to the fact that the London office enjoyed exceptional privileges, such as payment for Sunday duty and a higher status and maximum. Resolutions were passed specifying the several grievances that remain unredressed, calling upon the central committee to use every legitimate effort to obtain a parliamentary committee of inquiry, and expressing cordial sympathy with the clerk who had been suspended and removed from the Glasgow office for convening a meeting of his fellow clerks without the sanction of the authorities.—Other and similar meetings were held at Newcastle-on-Tyne, Birmingham, York, and elsewhere, on Saturday last. At Newcastle the clerks met at the Nag's Head, Cloth Market, delegates being present from Sunderland and Durham. In the course of the evening Mr. T. Spraggon (Newcastle), on behalf of the telegraph clerks stationed in the offices in the North of England, presented Messrs. G. Haddon and J. H. Clarkson with marble timepieces, as a slight recognition of the zeal and intelligence they have displayed in their endeavours to raise the status of the service. At Birmingham a meeting was held at the Acorn Hotel, Temple-street. The following resolutions were passed:—"That this meeting expresses its dissatisfaction with the scheme of revision applied to the Postal Telegraph Department in 1881, and is of opinion that the claims put forward in the petition of the telegraph clerks of the United Kingdom to the Postmaster-General of January 31, 1881, are just and reasonable, and, therefore, cannot regard as final any scheme which fails to satisfy those claims." "That we are of opinion that the best way of obtaining a satisfactory settlement of our grievances is through the appointment of a Select Committee of the House of Commons, and that we urge the Central Committee to use every legitimate effort to obtain that end." "That we strongly condemn the arbitrary action of the Glasgow authorities in their treatment of Mr. Robertson, of that office, by suspending him for posting a notice convening a meeting of his fellow clerks to consider what steps should be taken for the redress of their grievances, and that we offer him our hearty sympathy and support." "That this meeting tenders its cordial thanks to members of Parliament, the Press, and the public for their generous support in the past, and earnestly hopes that they will continue to render their support." Similar resolutions were passed at York.

Electric Lighting and Chelsea Vestry.—At a recent meeting of the Chelsea Vestry the report of the surveyor, Mr. G. H. Stayton, C.E., was read. It recapitulated what took place before the Board of Trade on the 17th Feb., congratulated the vestry at finding the conclusions of the board agreed with those of the vestry, and recommended that the new area arranged with the Brush Company be approved. Mr. Charles Mossop, the committee's chairman, moved the adoption of the report. He reminded the vestry that the scheme of the company was to take for their area of supply the whole parish, and for periods varying from two years and a half to twelve years and a half from the passing of the Act. The scheme might be said to be covered by the Act of Parliament, but it did not bear the stamp of Parliament, because it had never been suggested to the committee, nor was it ever referred to in the debates of either House. It seemed an evasion of what Parliament intended rather than a fair attempt to interpret the Act. The vestry opposed the scheme as regards space and as regards time. The latter was the more important item. Who could tell the value of a single year of electricity? The vestry has offered a very liberal alternative scheme. They have divided the parish into three blocks—A, B, and C—and the company has accepted block A, the easterly part of the parish. A is divided into two parts—blue and pink; blue is the smaller part, which the company has to light within two years and six months. As one stands in Pont-street, with his back to Sloane-square, looking to the north, there is a triangle of ground, of which Pont-street is the base and Knightsbridge is the apex. This takes in about fifty acres, including Lowndes-square, part of Cadogan-place, Charles-street (part), Sloane-street (part), Pavilion-road, Hans-place, Walton-place, and Walton-street (part). In round numbers this will cost £30,000. The company has to place their plans, specifications, and estimates before the Board of Trade, and if the figures are approved that sum will have to be set aside for this district, and all troubles as to payments for patents are at an end. Then the company can take a further part of the pink. The area must be agreed to by the vestry, and the money must be set aside for the second portion as before. This practically gets rid of bogus companies, and removes the difficulties as to subletting and assigning. The company have given up the clause in the provisional order which apparently overrides the Act, and this gets rid of the question as to over-head wires, and leaves the vestry with the control of their streets. Mr. Stayton's suggestion as to the wires being placed under the footways on each side of the street is accepted. The vestry has been for the last three months educating itself and (with the great aid that the Press has afforded them) other local authorities; and who knows that the Board of Trade has not been educated as well? All other local authorities will have the benefit of the vestry's labours. The Board wishes it to be known that they do not desire to interfere with local authorities. The vestry must decide which of two companies shall be preferred, and they must settle with the companies the area of supply. Mr. Culbertson seconded, thanking Mr. Mossop and the surveyor for the great trouble they had taken, and the motion was carried unanimously.

Extraction of Precious Metals by Electrolysis.—In a recent number of the *Chemical News* Messrs. Blas and Miest described several methods for the extraction of the precious metals from all kinds of ores by electrolysis. The following abstract of this paper was given in the *Journal* of the Chemical Society for January:—"The authors have discovered that if, in electrolysis, compressed ores are used as anode in a bath of an electrolyte containing the same metal as the metal of the ore, on the passage of the current the ore is decomposed, the sulphur, &c., being precipitated at the anode, whilst the metal collects at the cathode. Thus, with pure galena in a lead nitrate bath, the separation is complete and easy. If the ore contains silica as well, then the silica is deposited along with the sulphur, and remains uncombined. Antimony and arsenic, if present, behave in a similar manner, being precipitated as insoluble oxides. They are very easily separated by a subsequent electrolysis. When large quantities of arsenic are present, a part of it combines with the sulphur, and forms realgar or orpiment. When ores containing several metals are operated on, the precious metals, being most easily precipi-

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tated, are thrown down first in the metallic state at the cathode under the action of a moderate current. The final separation of these metals requires very little battery power, for the mass of metal when dissolved under the action of the current regenerates sufficient heat for the ulterior separation of each metal separately. The products at the anode are extracted and purified by treatment with carbon bisulphide, and afterwards by separate electrolysis. The decanted carbon bisulphide solution of sulphur is distilled, the latter being left pure. If the ore is a polysulphide, and is mixed with much iron, sulphur and iron oxide are obtained in the first operation. These are best separated by electrolysing in a dilute sulphuric acid bath; pure sulphur is obtained at the anode, and basic iron sulphate at the cathode. By this process $1\frac{1}{2}$ horse-power is required to produce one kilo of copper from a sulphurous ore in one hour. As an example of the working with a complex ore, they describe the treatment of an argentiferous lead ore containing iron, copper, and zinc. The current being sufficiently strong, the iron and zinc will dissolve as readily as the other metals, but will not be precipitated so easily, therefore the solution will gradually become saturated with iron and zinc; the current is then regulated so that only the lead, silver, gold, and copper are precipitated on the cathode while the zinc remains dissolved as nitrate. As the bath becomes saturated, the iron yields to the zinc, and is precipitated to the bottom as ferric oxide, and as soon as the solution is nearly saturated with zinc nitrate it is syphoned off; the metals are then removed from the cathode, the sulphur and silica from the anode, and the iron oxide from the bottom, of course all separately. The sulphur, &c., and the metals are treated as above described. The zinc nitrate solution is treated with a small quantity of zinc oxide, which throws down the iron; the lead, copper and silver retained (if any) are precipitated by passing a current through the solution, using a zinc anode. The pure zinc nitrate may be treated by a stronger electric current if metallic zinc is required, or chemically if zinc oxide is wanted."

THE VIENNA ELECTRIC EXHIBITION.—The time fixed for the receipt of applications for space has been extended from the 1st to the 20th inst., by which latter date they should be in the hands of the secretary of the Society of Telegraph Engineers, 4, The Sanctuary, Westminster. We are also authorised to state that the committee at Vienna are making arrangements for a reduction in the rates of transit on all goods forwarded to Vienna for exhibition. From information received from Vienna it seems that the Exhibition is likely to prove thoroughly international, as well as comprehensive. Experiments as to the transmission of power will be carried out by M. Deprez and others, for which 300 h.-p. is available at different places round Vienna, and at various distances up to sixty kilometres. A recent telegram from the *Standard* Vienna correspondent gives some details which are of interest. With reference to his remarks on M. Deprez's experiments, however, we would refer our readers to an article in another column. He says:—"The Crown Prince (Rudolph), who is now on a visit to Berlin, will communicate with the German Committee, which, with the help of the Electro-Technical Society, and men like Dr. Werner Siemens, is expected to bring together a great collection of the most important recent appliances. The Americans will also probably take a prominent part in the Exhibition, but, owing to the great distance, they are among the latest to send in their announcements. Although England, Germany, and America are all late in their applications, the Vienna Committee have sufficient promises to make it pretty certain that those countries, in common with the nearer Continental States, will be well represented. Such an opportunity, in fact, as the Vienna Exhibition will offer for the extension of the electric light and other applications of electricity in the East of Europe, in Russia, Roumania, Servia, Greece, and Turkey, as well as in Austria and Hungary, is not likely to present itself again for a long time to come. The Exhibition will be held in the Prater, the great park of Vienna, and the favourite resort of the vast population of the city throughout the summer. The building in which the display will be collected is the Rotunda, the largest covered hall upon the European Continent. The space over which this edifice extends is more than a quarter of a million square feet, being more than double the area available at the late exhibition at Munich. Among the principal features of the Exhibition I may mention, in the first place, the exhibits of M. Marcel Deprez, whose developments of electric art in the way of transmission of electric power are among the most important of recent times. At Munich M. Deprez was able to use in the Exhibition the water power furnished by a small cascade thirty-five miles distant, the medium of transmission being nothing more than an ordinary telegraph wire. The loss of power then, however, was slightly over 60 per cent. By the help of improved machinery he has already reduced this loss very considerably, and he expects to show still better results at the Vienna Exhibition, where his experiments will be shown on a grand scale, and where he promises to prove to demonstration the entire correctness of his views on the transmission of electric force. There will likewise be rivals in the same section in the persons of M. Gravier, of Warsaw; M. Ganz, of Pesth; and M. Krizik, who is already known as the inventor of the Pilsen lamp. M. Gaston Planté, inventor of the accumulator, and M. Gautheret will also be among the exhibitors in this new field. Another department in which much that is novel and surprising will be shown will be that having to do with scientific measurements connected with electricity. Since the Munich Exhibition there has been remarkable progress made in this section, which will be fully illustrated in Vienna. The measurement of the degree of light in the various electric systems will here be illustrated. There will also be a few new systems of electric lighting shown, both of the arc and incandescent descriptions. Messrs. Krizic and Scoda, of Pilsen, will show a single arc light equal to twenty thousand candles in effect, and produced by a sixty horse-power engine. The Société Anonyme, of Paris; Edison's Company, of New York; and Deckert and Thomalto, of Vienna, will also compete with various novelties in this department. Another interesting portion of the Exhibition will refer to new applications of electricity for various scientific purposes, including electric optical instruments, medical appliances, apparatus for the examination of the interior organs of the body, and electrolithic batteries. There will also be new electric railway signals, electric rail shifters, point indicators, electric type-printing with single wire, and a new phonophone for musical transmission. There will be an electric railway running through the principal avenue of the Prater to the Exhibition. Some of the Vienna theatres are also to be connected with the Rotunda by telephone, so that the performances may be heard in the Exhibition. The Baden Theatre, ten miles distant, will be similarly connected. From this somewhat brief sketch it will be seen that the Vienna Electrical Exhibition of 1883 promises to be full of interest, not to the electricians and specialists only, but to the travelling public generally."

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CURRENT ENERGY.—III.

BY OLIVER HEAVISIDE.

We have next, in natural order, to consider the potential energy of a current system on itself, as distinguished from its energy with respect to another system. The last being called the mutual energy, we may for brevity term the former the self-energy, just as the induction of a current on itself is called self-induction. The meaning of self-energy follows plainly from that of mutual energy; and hence, after the method previously given (p. 343), we may define the self-energy (potential) of a current system to be amount of work spent by externally applied forces against the electro-magnetic forces in building up the system by bringing together to their required positions from an infinite distance all the infinitely fine tubes of current into which the system may be split up, each infinitely small current being of constant strength. Now this amount is always negative (as is plain in simple cases, and is proved for an arbitrary system below), though the mutual energy of two systems may be positive or negative; hence the self-energy (potential), with sign changed, is the work needed to pull the system to pieces against the electro-magnetic forces, finally bringing it to a state of division into infinitely fine tubes, infinitely widely separated.

The calculation may be made by the same method of pairing tubes as for the mutual energy, with one important difference, however, which, when attended to, allows the method to give us the formula for the self-energy. Divide the system into, say, n tubes, and remove them, one at a time, to an infinite distance. Or, simply turn any tube in the act of removal into such a position that the total amount of magnetic force through it arising from that part of the system which remains is *nil*, and then cancel it. The required total amount of work performed is obviously the sum of the mutual energies, first of No. 1 tube with respect to the remaining $(n-1)$; then of No. 2 with respect to the remaining $(n-2)$, and so on. Thus, in pairing the tubes, we count each once only with respect to all the rest, or we form all the different pairs that can be made in the system.

Now, imagine there to be another system, exactly equal to the first, and coincident therewith. In calculating their *mutual* energy, we should form all the pairs that can be made, taking one member from the first, and the other from the second system. Now, we have, for example, the mth tube in the first paired with the n'^{th} in the second system, and also the n'^{th} in the first paired with the m'^{th} in the second. But the energies corresponding to these two pairs are equal, by the assumption that the systems are exactly equal. So the pairing is the same as if, in the previous case (for the self-energy), we had counted every pair twice over, with only this difference, that we have additional pairs 1,1′, 2,2′, 3,3′, &c., the accents referring to the imagined system. But the sum of the energies corresponding to these pairs, when the subdivision is carried to extremes, becomes infinitely small compared with the sum of all the rest. Hence we have the result that the self-energy of a system is exactly one-half its energy with respect to an exactly equal coincident system. The latter we know to be $\Sigma\overline{AC}$, where C is the current and A the vector-potential of either system. Consequently, if M_1 be the self-energy, we have

$$-M_1 = \frac{1}{2}\Sigma\overline{AC} \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Any other method, properly carried out, will lead to the same result. Thus, first divide the system into two coincident systems, each of half the strength, and, therefore, having the vector-potential halved as well as the density of current, and separate them. The work done is $\frac{1}{2}\cdot\frac{1}{2}\Sigma\overline{AC}$, being their mutual energy, with sign changed. Next, similarly divide the two halves into systems of a quarter the currrent density and vector-potential, and separate as before. The work done is $2\cdot\frac{1}{4}\cdot\frac{1}{4}\Sigma\overline{AC}$. In the third similar operation the current and vector-potential are $(C \div 8)$ and $(A \div 8)$ and there are four pairs; hence the work done amounts to $4\cdot\frac{1}{8}\cdot\frac{1}{8}\Sigma\overline{AC}$. Carry this on *ad infinitum*, and sum up the amounts of work spent. The result is

$$\Sigma\overline{AC}\left(\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\ldots\right) = \frac{1}{2}\Sigma\overline{AC} \text{ as before,}$$

since the sum of the series $= \frac{1}{2}$.

Collecting results, let M_1 and M_2 be the self-energies, M_{12} the mutual energy of two arbitrary systems, in which C_1 and C_2 are the currents, and A_1 and A_2 the vector-potentials, and let M be the complete energy. Then we have

$$-M = -(M_1 + M_2 + M_{12}) = \frac{1}{2}\Sigma\overline{A_1C_1} + \frac{1}{2}\Sigma\overline{A_2C_2} + \Sigma\overline{A_1C_2} \quad . \quad . \quad . \quad (2)$$

where, instead of the last term, we may write $\Sigma\overline{A_2C_1}$.

We may easily show that (2) is consistent with (1) by regarding the two systems as a single one. For the actual vector-potential at any point is the vector-sum of A_1 and A_2, say A. Now if we substitute for the last summation in (2) one half of $(\Sigma\overline{A_1C_2} + \Sigma\overline{A_2C_1})$, which we may do because the two sums are equal, and rearrange terms, we get

$$-M = \frac{1}{2}\Sigma(\overline{A_1C_1} + \overline{A_2C_1}) + \frac{1}{2}\Sigma(\overline{A_1C_2} + \overline{A_2C_2})$$
$$= \frac{1}{2}\Sigma\overline{AC_1} + \frac{1}{2}\Sigma\overline{AC_2}.$$

(See rule on p. 343). Therefore, if the systems nowhere overlap, this is reduced to $\frac{1}{2}\Sigma\overline{AC}$, extending the summation over both systems. And when they do overlap it is the same. For in the overlapping parts the actual current is the vector sum of C_1 and C_2, hence we are reduced to $\frac{1}{2}\Sigma\overline{AC}$ always, agreeing with equation (1) for the self-energy of a system.

There is another very important and significant expression for the energy, which involves a transformation of an extraordinary character. Expressed generally, it amounts to this:—Let A be any vector function of no convergence, B its curl, and C that of B, then

$$\Sigma\overline{AC} = \Sigma B^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad (3),$$

the summations being taken throughout all space; or, which comes to the same thing, the first summation extended to all places where C exists, and the second over all space where B exists. A, B, C are here defined exactly as for the volume-element of a current, viz., amount crossing unit of area × volume, and taking the volume-element as the unit volume. By making use of the fundamental theorem connecting a vector and its curl, and by following the tubes of flow in our summations, the proposition admits of proof in a manner which makes evident how the transformation takes place.

Since B and C are non-converging, these systems may be completely divided into tubes of flow (*i.e.*, of flow as applied to a liquid), which are all closed. We shall first prove (3) in the case of a single tube of C, which may have any form, but is of indefinitely small section; *i.e.*, C = 0 everywhere except along a certain closed channel across every section of which we have a constant amount of C, which we may call C_1. Let B_1 and A_1 be the corresponding values of A and B. (A_1 is the vector-potential of C_1, and B_1 the curl of A_1, as before shown.) We know by the fundamental relation (Theorem II., p. 56 *ante*) that the line-integral of B_1 once round any closed curve = whole amount of C_1 through the curve; hence the line integral is zero unless the tube of C_1 goes through it (the closed curve). Now, the system B_1 is wholly made up of closed tubes, and since, if we integrate B_1 once round one of them, we always get a finite result (because the direction of B_1 is along the tube), it follows that *all* the tubes of B_1 pass through the circuit of C_1 and complete their circuits outside.

Let any surface be described whose edge is bounded by the

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circuit of C_1; then, by what was said last, it cuts all the tubes of B_1. Next, let it be so situated as to cut them at right angles, and describe a series of other surfaces indefinitely close together, all similar to the first in that they are bounded by the circuit of C_1 and cut the tubes B_1 perpendicularly. This is possible, because in space where B_1 has no curl, that is, wherever $C = 0$, or everywhere except within the tube of C_1, B_1 may be derived from a scalar potential; and these surfaces are the equipotential surfaces. (We need not consider any correction in the following due to B_1 within C_1, because we take that space infinitely small.)

We have to prove that $\Sigma \overline{A_1C_1} = \Sigma B_1^2$. Now the summation $\Sigma \overline{A_1C_1}$ extends only to the tube of C_1. Hence

$$\Sigma \overline{A_1C_1} = C_1 \times \text{line-integral of } A_1 \text{ once round } C_1 \quad . \quad . \quad . \quad (4.)$$

(not meaning round C_1 in the sense that a tube of B_1 goes round C_1, but along the tube of C_1). But $B_1 = \text{curl } A_1$, therefore (4) becomes (by Theorem II., p. 56)

$$\Sigma \overline{A_1C_1} = C_1 \times \text{integral of } B_1 \text{ over any surf. bounded by } C_1 \quad (5.)$$

But again, $C_1 = \text{curl } B_1$, therefore (Theorem II.)

$$C_1 = \text{integral of } B_1 \text{ once round any tube of } B_1 \quad . \quad . \quad . \quad (6.)$$

Hence, by substituting (6) in (5) we find

$$\Sigma \overline{A_1C_1} = \left.\begin{array}{l}\text{line-integral of } B_1 \\ \times \text{ surface-integral of } B_1\end{array}\right\} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7.)$$

It is important to notice that *any* tube of B_1 will do for the line integral, and *any* surface bounded by C_1 for the surface-nitegral. But all the tubes of B_1 are cut by the surface, and when it is an equipotential one they are cut perpendicularly. The same being true for the whole series of equipotential surfaces, it follows that the product of the line and surface-integrals in (7) includes every place where B_1 exists; hence we may ignore the tubes completely, and write

$$\Sigma \overline{A_1C_1} = \Sigma B_1^2,$$

extending summations through all space; whence the proposition is proved in the case of an infinitely fine tube of C.

Now, in the general case of an arbitrary system, divide C into its tubes, and consider one of them, say, C_1, as before. We have A and B instead of A_1 and B_1, and $\Sigma \overline{AC_1}$ instead of $\Sigma \overline{A_1C_1}$; hence, by the previous reasoning,

$$\begin{aligned}\Sigma \overline{AC_1} &= C_1 \times \text{line-integral of A round } C_1, \\ &= C_1 \times \text{surface-integral of B,} \quad . \quad . \quad . \quad (8)\end{aligned}$$

the latter being over any surface bounded by C_1. Divide space as previously by means of the equipotential surfaces of B_1 and the tubes of B_1 (not of B). The tubes of B will not, save exceptionally, cut the surfaces at right angles, hence we have to take the normal component of B in the surface integral in (8); that is, B cos (BB_1). Also C_1 has the same relation to B_1 as before; therefore, by (6) and (8),

$$\Sigma \overline{AC_1} = \left.\begin{array}{l}\text{line-integral of } B_1 \\ \times \text{ surface-integral of B cos } (BB_1)\end{array}\right\} \quad . \quad (9)$$

But $BB_1 \cos (BB_1) = \overline{BB_1}$, and the space integrated over is as before; therefore,

$$\Sigma \overline{AC_1} = \Sigma \overline{BB_1}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

Similarly for a second tube of C, say C_2, we shall have $\Sigma \overline{AC_2} = \Sigma \overline{BB_2}$, and when we do the same for all the tubes of C, and add, we get

$$\Sigma \overline{AC} = \Sigma (\overline{BB_1} + \overline{BB_2} + \overline{BB_3} + \ldots).$$

But B is the vector sum of B_1, B_2, &c.; whence the bracketted quantity in the last equation $= \overline{BB} = B^2$; therefore, finally,

$$\Sigma \overline{AC} = \Sigma B^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

for any arbitrary system.

[I think it was a philosopher who propounded the theory that men always thought in some language; an Englishman in English, for example; always, if he knew no other language; otherwise he might think in either. Not to raise the obvious objection that persons dumb from birth should, according to this, have no thoughts at all, the theory is certainly proved to be false by an examination of such a transformation as the above. As regards the case of a single tube of C, if only the geometrical conditions are pictured in the mind, the division of space into small cubes by the tubes of B_1 cut across by the equipotential surfaces of B_1, the transformation becomes as self-evident as an axiom, and no form of words or sentences is necessary. The less one is cumbered with them the better. And, although the extension to an arbitrary system is less easy, it is still easier to be pictured than logically demonstrated. The transformation might have been seen quite intuitively; it is only when one has to prove it to some one else that clothing the thoughts in words becomes necessary; and, even then, the clothes do not correspond to the original thoughts, but to those arising in the act of description, and both words and thoughts require to be readjusted, perhaps, two or three times before they will mutually fit with any decency. The Cartesian transformation, breaking up each of the vectors A, B, C into three rectangular components, is short enough, but with a total absence of visible reason and significance.]

In applying (11) to electro-magnetism, we have to remember that, B standing for the magnetic force, C for current, and A for the vector-potential, we have $B = \text{curl } A$, but $4\pi C = \text{curl } B$. Consequently the potential self-energy of a current system is, by (1) and (11)

$$-\frac{1}{2}\Sigma \overline{AC} = -\frac{1}{8\pi}\Sigma B^2 \quad . \quad . \quad . \quad . \quad (12).$$

Now, go back to (10). The left-hand member is the mutual potential energy with sign changed of an arbitrary current system whose vector potential is A and of a single tube of current C_1. In the same manner as (11) followed from (10) we may easily show that the mutual potential energy of two arbitrary systems denoted by the suffixes 1 and 2 is

$$-M_{12} = -\Sigma \overline{A_1C_2} = -\Sigma \overline{A_2C_1} = -\frac{1}{4\pi}\Sigma \overline{B_1B_2} \text{ also } (13).$$

Hence, in terms of the magnetic force, equation (2), for the complete energy of two systems, becomes

$$-M = \frac{1}{8\pi}\Sigma B_1^2 + \frac{1}{8\pi}\Sigma B_2^2 + \frac{1}{4\pi}\Sigma \overline{B_1B_2},$$

which is obviously reducible to $\frac{1}{8\pi}\Sigma (B_1 + B_2)^2$ or $\frac{1}{8\pi}\Sigma B^2$ if B be the actual resultant magnetic force.

The expression $\Sigma B^2 \div 8\pi$, that is, the potential energy with sign changed, may be proved, though not without reference to induction phenomena, to be the Energy of a current system, or its capacity for performing work in various ways. The form in terms of the square of the magnetic force, due originally to Sir W. Thomson, is of great significance in the theory of action through an intervening medium, as opposed to action at a distance.

THE ELECTRICAL EXHIBITIONS.

This winter we have to chronicle two exhibitions, the one at the Crystal Palace, the other at the Aquarium. As our readers know, the former of these is a mixed exhibition—being devoted partly to electricity and partly to gas—while the latter is purely electrical. The exhibition at the Palace has, we are told, proved very attractive, although the electrical portion is by no means extensive or complete. The exhibition at the Aquarium is also in a very incomplete state; indeed, the formal opening has been put off from time to time because of such incompleteness, but it is stated on good authority that it is to be really opened this week. The promoters of this exhibition, no doubt, hope that the special appropriation of the Aquarium for such a display is to be found in Dante's line, which may be rendered:—

Whereby in compass small may much be shown.

For, when compared with Paris and the Palace Exhibition, the space is, indeed, small. We gather, however, that the most will be made of the space at command, and should the exhibitors who have promised fulfil their promises there will be a goodly display of light apparatus. Several of the larger companies are not directly represented at either of these

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exhibitions, thinking, no doubt, to keep their energies for Vienna or Berlin, or other international exhibitions. It may be that their wares are so well known as to need no further display. At any rate, the absence of one class of exhibitors cannot but be of advantage to another class, and, in some manner, to the public generally, allowing, as it will, some of the poorer and more modest inventors to show what they can do, and so allow of comparisons which could hardly be made where one man shows two or three lamps in proximity to a dozen or a score of another exhibitor.

There is or will be at the Aquarium a number of new arc lamps, as well as new dynamos, new secondary batteries, and other new apparatus connected more or less with electric light work. We will commence our report with a description of a new dynamo.

The Lumley Dynamo.

The peculiarities of this dynamo are in the construction of the armature. The machines have been constructed by Messrs. Paterson and Cooper, from the designs of Mr. Lumley. According to a list we have before us, two classes of machines are made. One kind for incandescent lighting, the other for arc lighting. Several types of machines are made in each class. Thus:—

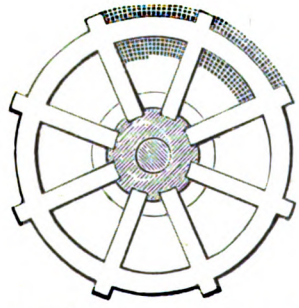

Fig. 1.—Armature Core of the Lumley Dynamo.

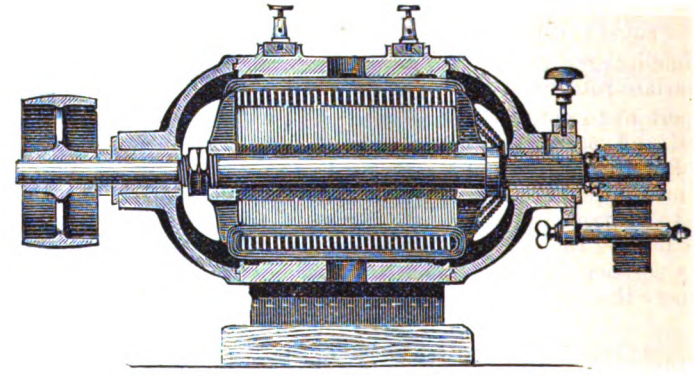

Fig. 2.—Section of Lumley Dynamo.

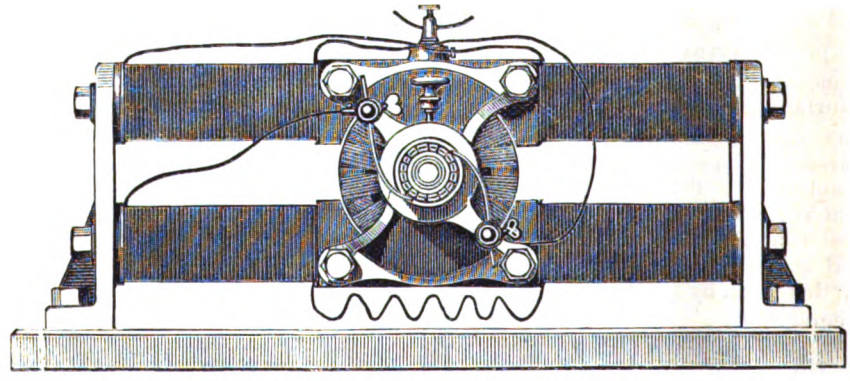

Fig. 3.—View of the Lumley Dynamo from the Commutator side.

For Incandescent Lighting.		For Arc Lighting.	
No.	No. Swan Lamps, 20 C.-P.	No.	Indicated H.-P. required.
1B	50	1A	4
2B	70	2A	5
3B	100	3A	9
4B	200	4A	18
5B	500		
6B	1,000		

Indicated H.-P. required.	No. of Lights.
4	4
5	5
9	9
18	18

The above figures are those issued by the company. It will be seen that a very high efficiency is claimed. Taking the 45 volt Swan 20 C.-P. lamp as requiring 1·3 ampere current, the maximum number of lamps that could be maintained per H.P. would be less than 13. This, of course, supposes the whole of the energy to be expended in the lamp. If, therefore, with this machine between 11 and 12 lamps can be maintained per H.-P., the result is very good. Before entering into particulars regarding the construction, we may say that the machines are very compact, the 70 light machine, for example, measuring only 2ft. 6in. by 2ft. 6in. by 1ft. 5in. over all, and weighing somewhat less than 4½cwt. There is little difference in the field magnets to those of other machines. The arms are of cast iron, and of a flattish section. The shaft carries a grooved cylinder. The core of the armature consists of sheet iron discs cut into the form of a wheel, as shown in Fig. 1. The spokes of the wheel may or may not project beyond the rim, the other end of the spokes going into the groove on the shaft. The core is built up alternately of these iron discs and brass rings, the brass rings being placed at the shaft end of the discs, and being comparatively narrow. The core thus built up is wound longitudinally with insulated wire around the rims of the discs in the ordinary manner, each section or bobbin being separated by the spokes, and as these are equidistant the quantity of wire in each bobbin is similar. The discs are all punched by machinery. The armature, at least the larger sizes, can be wound by machinery, hence the cost of the machines is lessened, and the company claims it to be the cheapest machine in the market. The designers have also invented a new arc lamp, which is very simple, and will be seen at the Aquarium. We shall refer to this lamp in a future issue.

Messrs. Paterson and Cooper have favoured us with the following figures concerning these machines. Readings of a shunt machine gave 74·2 amperes current at an electromotive force of 46·25 volts at the terminals, the external circuit having a resistance of ·62 ohm, and the speed being 1,680 revolutions per minute. The resistance of the armature of the shunt machine is ·079 ohm, that of a series machine about 1 ohm, the resistances of the field magnets in the former case being 7·79 ohms, and in the latter about 1 ohm. The E.M.F. of the series machine is about four times that of the shunt. Altogether it will be seen the machine is one that will bear careful examination, and we hope to refer to it again during the exhibition. Fig. 2 shows a section of the machine, whilst Fig. 3 is a view from the commutator side.

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THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONTINUED FROM PAGE 376.)

When a submarine cable is completely broken it frequently happens that the copper wire is broken half an inch or more from the place where the gutta percha envelope is fractured. In some cases the copper protrudes, and in others the end is within the gutta percha. When testing for the distance of the fault the resistance measured will be the resistance of the copper conductor to the fracture, plus the resistance caused by the end not maintaining a perfect earth connection, for the resistance of the small column of water, half an inch long and only about a sixteenth of an inch in diameter, is considerable. To eliminate this unknown quantity is the great difficulty in the way of finding the distance of the fault, for if the copper wire touched, say, the iron of the cable, the fault would give no resistance, and the resistance found when testing would be the actual resistance from shore to fault, from which, of course, the actual distance can be found. The discharge of the dynamic charge it will be seen (theoretically, at any rate) gives us the means of finding the resistance of the fault. For let A B (Fig. 53) be the actual resistance of the conductor to the fault, and B C that of the fault. Then, if we applied a battery at A, the resistance of which was D A and the electromotive force D E, we should have a dynamic charge which, instead of being equal to the triangle A F C, would be only equal to the figure A F G B. A portion of this dynamic charge, when A is put to earth, would go to earth at C and a portion at A. This last portion, the "return current," can be measured, and it is evident that

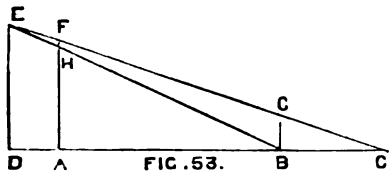

FIG. 53.

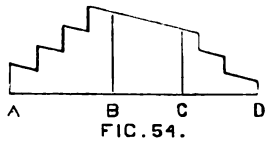

FIG. 54.

since, if the end always made good earth, then the portion discharging at C would bear some regular proportion to that resistance, that when the discharge (or "return current") is *less* than that proportion, then it must show that *some of the resistance is due to resistance having no electrostatic capacity.* If the line made a perfect earth at B (as by touching the iron wires), then the resistance would be A B, and the dynamic charge would be A H B, and if the resistance shown was A B, and we had a return current proportionate to the dynamic charge A H B, we should know that the end made a perfect earth, and, consequently, that the resistance shown by test was the true resistance to the fault. This reasoning I pointed out in a paper I read before the Institution of Civil Engineers on 23rd February, 1858. Since then Dr. Werner Siemens has solved the complete problem, and worked the proportions out, and Mr. Kempe has not only also done this, but devised instruments for taking the test accurately. The problem in its entirety is, it will be seen, very abstruse, because we have first to find the proportion of the dynamic charge that would, if there was a perfect earth at B, discharge at A. This, I believe, Mr. Kempe makes two-thirds of the total charge. Now, when the resistance is increased by the fault the total charge is increased, but not in proportion to the increase of resistance. It is less than it would be if all the resistance was due to cable by the amount of the triangle B G C. And again, of this total charge a greater proportion will come out at A than in the case of the charge A H B, so that the relation between this return current and the resistance shown is excessively complicated; but it has, nevertheless, been, as I have said, solved. In extreme cases, however, it is a guide even without the exact formula. For instance, suppose the resistance shown by test very great, say equal to two hundred miles, whilst the return current only equalled what would be given by two or three miles of cable, then we know at once by the great discrepancy that a great portion of the resistance is due to the fault. It happens sometimes that the resistance shown is infinite, from the end becoming completely sealed up. The gutta percha being the last to give way, and the cable, when the wires are gone, twisting round rapidly, draws the gutta percha over the end of the copper, and then twists it up in the most workmanlike manner. In such cases, by charging the cable up and measuring the discharge, we have the only means of measuring the distance, and this is, in fact, a very reliable test.

When a battery is in opposition to another it will take the form shown in Fig. 54, where A B is a battery opposing C D and having a greater electromotive force. The ends of submarine cables through polarisation set up an electromotive force, and this opposing the testing battery current causes the resistance measured to be either greater or less than the real resistance to the fault, according to the nature of the electromotive force set up. This is shown in Fig. 55, where A B is the real

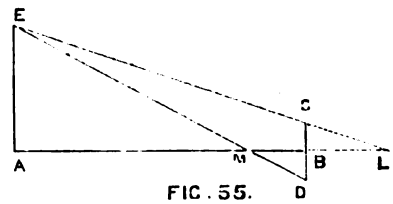

FIG. 55.

resistance to fault, and A E potential at A, when testing. Then if the electromotive force set up at the fault is B C (*i.e.*, positive), the resistance measured will be A L, too great by B L, and if the electromotive force set up is B D (*i.e.*, negative), then the resistance shown will be A M, which is too small by M B. It will be seen that B is not half way between M and L, and the mean between the two tests is not the accurate distance of the fault. However, I am not writing a treatise on testing, but only illustrating the subject geometrically, and before leaving the subject of the conductive circuit it may be well to illustrate geometrically a few of the ordinary testing instrument circuits. Thus, a differential galvanometer and resistance, being compared, is shown in Fig. 56. A E is the potential of the battery pole applied to instruments at one

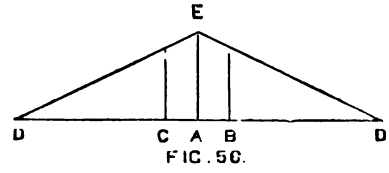

FIG. 56.

terminal, A C and A B resistance of the coils, and D C and B D the measuring and unknown resistances, the one being measured by the other. The current being equal in each coil when the needle is at zero, the steepness of the potential line in each branch of the circuit is equal, and thus that line cuts off equal resistances on each side of A.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—An extraordinary general meeting of this company will be held at St. Michael's Hall, George-yard, Lombard-street, E.C., on the 15th March, at two o'clock, for the following purposes:—1. To declare a dividend of £3 per cent. on the (reduced) capital of the company (in accordance with the recommendation contained in the annual report, dated January 3, 1883, adopted by the shareholders in general meeting on January 11, 1883) for the year ending September 30, 1882, the necessary resolutions for the reduction of capital having been duly passed and confirmed by the shareholders, and sanctioned by the Court on February 16, 1883. 2. To submit resolutions in accordance with a requisition signed by shareholders holding over 11,000 shares, referring to the conversion of existing Ordinary shares into Preferred Ordinary shares and Deferred Ordinary shares. Holders of share warrants wishing to attend the meeting must deposit the warrants at the offices of the company, with name and address, three days at least before the day appointed for the meeting.

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CORRESPONDENCE.

THE INVENTOR OF THE TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As your editorial note of p. 374 invites me to give the references that I have indicated in evidence of Reis's claim to be the inventor of the telephone, which he designed for the express object of transmitting human speech and other sounds of all kinds, I have much pleasure in giving you the very same references which I have myself obtained from the published writings of Graham Bell ("Researches in Telephony," *Journal of Society Telegraph Engineers*, 1877) and of Edison (see "Prescott's Speaking Telephone," p. 218).

The following are a few of Bell's references:—

(1) "Telephonie," *Dingler's Polytechnisches Journal*, CLXVIII., p. 185, extracted from the *Jahresbericht des Physikalischen Vereins zu Frankfurt am Main*, 1860-61, p. 57-64.

This is a scientific memoir by Philipp Reis, having for title "On Telephony by the Galvanic Current." On p. 58 he says his endeavour was to find an instrument which should reproduce the total action of all the organs set in action in human *speech* (menschlichen Spräche), and that he took the human ear as model, because the tympanum of the ear could respond to all sounds. After discussing the problem of representing the pressures of the air in sound-waves by a "curve," he says that if it is possible at any place to reproduce vibrations having a similar "curve," the very tones will be reproduced. He then says that, taking his stand on the principles laid down, he has succeeded in reproducing the tones of various instruments, and to a certain degree the human *voice* (die menschliche Stimme). After describing his instrument—the well-known combination of a tympanum in imitation of that of the human ear, with an electric current regulator, consisting of an interrupting apparatus, which embodied the loose-contact principle of the microphone, and which is in many respects exactly like the interrupter in the Blake transmitter—he says (p. 62):—"I give to my instrument the name 'Telephon.'" Later on he says that the reproduction of human speech which he has attained is not so clear as to satisfy everybody, and that though the consonants are transmitted distinctly enough, the vowels are not equally so, and he proceeds to discuss why this is the case.

(2) *Brix's Zeitschrift des deutsch-oesterreichischen Telegraphen Vereins*, 1862, Vol. IX., p. 125. This article is also reprinted in *Dingler's Polytechnisches Journal*, 1863. Bd. CLXIX., p. 23.

This is a report by Inspector von Legat on Reis's telephone in its developed form. Inspector von Legat says that this instrument was able to reproduce single words uttered as in reading and speaking, though not so distinctly as it reproduced chords and melodies, which latter it transmitted with marvellous fidelity. He even added that the inflexions of the voice, the modulations of interrogation, exclamation, wonder, and command attained distinct expression!

So much for Bell's references; Edison's reference is the same as No. (2) of the preceding.

As to the publicity of these documents, permit me to refer you to the shelves of the British Museum and other public libraries.

I do not say that there is not plenty of further evidence, were such needed. But here I am quite content to accept the references given by such unimpeachable authorities as Bell and Edison. When they refer me to papers wherein Reis says in substance:—"I am the inventor of the telephone. My instrument is intended to transmit human speech and all other kinds of sounds that a human ear can hear, and it succeeds in doing so, though I find to my disappointment that it is not yet quite perfect, because though single words and consonants come through all right, the vowels are not clear," I am bound to believe, on the authority of Bell and Edison, who give me these references, that Reis's modest claim is just. And I am bound to this belief still more strongly because I find, when I make careful trial of Reis's own telephones, that they will do exactly what he said they were intended to do—namely, transmit human speech to a distance by the agency of the galvanic current.

You have, Mr. Editor, most aptly said that the question is what was *the kind of success aimed at* and attained by Philipp Reis? and I entirely agree with you that this question is not in the least degree affected by whether Philipp Reis is dead or alive. Though himself be dead, and the task of defending his memory from outrage falls to others, his words still live to testify in the most unmistakable manner to the aim which he set before himself, and to the measure of success which he attained in his invention of the telephone.—Yours, &c., SILVANUS P. THOMPSON.

Bristol, March 4, 1883.

P.S.—There is a slight *erratum* in line 12, from bottom of p. 373, where, by mischance, the word which I wrote has been altered from *perfected* to *perfect*. Philipp Reis's telephones of 1862 were not perfect, but were perfected instruments compared with those he showed to the Physical Society in 1861.

THE ERG-METER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In Mr. Shoolbred's lecture "On the Measurement of Electricity for Commercial Purposes" a description was given of Professors Ayrton and Perry's erg-meter, certainly the most simple of all the instruments described at this lecture. In the discussion Professor Perry laid great stress upon the point that in the erg-meter no new mechanical difficulties have to be overcome, as the experience acquired by the Clerkenwell clockmakers during the last 150 years would be quite sufficient to produce a mechanically perfect instrument. This is undoubtedly the case. But is the instrument mathematically correct? Mr. Shoolbred did not enter into its theory so as to prove that the retardation of the clock during a certain time is strictly proportional to the energy consumed in that time. To give an example:—Say, a householder uses during one week 10 amperes (at 100 volts) for four hours every day, and finds that his clock has retarded one hour during that week. Now, assume that in the following week he uses 50 amperes (at 100 volts) for eight hours every day, will the retardation of the clock be ten hours during this second week? This is a question which does not depend upon the experience of the clockmaker, but simply upon the correctness of the principle on which the erg-meter is based. Can any of your readers inform me where a theory of this instrument can be found; or, if none has as yet been published, would it be asking too much of Professors Ayrton and Perry's kindness to give to the world mathematical proof that the erg-meter is not only exceedingly simple and ingenious, but also accurate?—Yours, &c., PENDULUM.

TELEPHONIC TRANSLATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Without in the least traversing Mr. T. D. Lockwood's assertion, to which you refer in your last issue, that he used telephonic repeaters similar to mine in the United States in the autumn of 1879, I beg most emphatically to assert that such instruments were unknown in the United Kingdom at the time mine were designed, and, further, that none of the many American electricians who were brought over early in 1881 by the National Telephone Company, and who were engaged expressly because they were supposed to be conversant with all the latest American improvements, had ever heard of such a device. Two of these gentlemen even reported to the company that the only solution of the problem was to run metallic loops for every subscriber, and one of them, while I was making my experiments, repeatedly urged me to lose no time, as he was anxious to get a certain trunk wire working. As Mr. Lockwood states that he found his repeaters of little practical value and abandoned them in consequence, it is obvious that they could not have been of the same construction altogether as mine, which are, in

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every way, a complete success. The reference he makes to the Blake transmitter coil is not quite in order. That is a coil for transforming quantity currents into tension currents; mine is one for inducing tension currents by tension currents. A Blake transmitter coil will not translate between wire and wire, nor, on the other hand, will my coil do the duty of a Blake transmitter one.—Yours, &c., A. R. BENNETT.

134, Douglas-street, Glasgow,
March 3rd, 1883.

SAFE WORKING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the last number of *The Electrician* the supplement contains some data which are very much wanted. As I have worked a good deal in this direction myself I may perhaps be permitted to make a few remarks. The table gives the current which can be *safely worked* in conductors of different thicknesses. Now, what is meant by safe working? Most people would say that to work safely we must have a current which does not heat the wire more than a certain number of degrees. I have already pointed out that, theoretically, the square of the safe current should be proportional to the cube of the diameter, although in practice it seems to be not exactly so. But I have also shown that certainly the safe current is neither theoretically nor experimentally in any degree proportional to the area of section of the wire. Yet this is the law which is assumed in the table which forms the supplement. The subject is most important, and such a table is, as I have said, very much wanted. I hope, therefore, that you will inform us upon what experimental data the table in question is founded, what is meant by "safe working," whether the wire is bare or covered, if the latter with what thickness of material, and what temperature is considered permissible.—Yours, &c.,

34, Great George-street, Westminster, March 5, 1833. GEORGE FORBES.

THE SUPERPOSITION OF CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The principle that, in a network of wires, the resultant current may be calculated as the sum of the separate and independent effects of the sources of E.M.F. in the system is very well known and used (it must be very generally used, I should say) by those who have to perform electrical calculations.

It results at once from the well-known and fundamental principle that the stream function belonging to any fluid motion is additive; and the recognition of this principle involves *ipso facto* the perception of the additive nature of the currents in a network. The employment of this principle simplifies calculation in Wheatstone bridge and other network arrangements of wires, as Mr. Blakesley observes in his article of last week.—Yours, &c., GEO. M. MINCHIN.

R.I.E. College, Cooper's Hill.

AN ARC LAMP TO BURN AT ANY ANGLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to state that I have devised an arc lamp to burn at any angle, the same being done by an improved form of clutch, which forces the carbons to their just position by small, quick impulses. Should like a communication from "Inquirer" should he require such a lamp.—Yours, &c.,

OLIVER H. KENNEY.

1, Alice-villas, Woodhouse-road,
Leytonstone, E.

[We have received a similar letter from Mr. R. Bowman, of the same address, which evidently refers to the same lamp. —ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In answer to your correspondent, "Inquirer," I beg to inform him that my lamp, now exhibited by Mr. Werdermann, in the Alhambra Court and Tropical Department, Crystal Palace, can be made to burn at any angle, or will burn by having the carbon fed upwards any length that may be required for lamp posts.—Yours, &c., JOHN LEA.

43, Clarence-gardens, Osnaburgh-street,
Regent's Park, March 6, 1883.

LINES SUGGESTED

ON READING "W.'s" LETTER IN "THE ELECTRICIAN," MARCH 3, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

The man who signs with a zig-zag-zig,
Followed by spirals five,
Doesn't believe
In accumulators—
Doesn't, as he's alive.

Who is the man with the zig-zag-zig
Followed by spirals five?
'Tis Mister ————,
Who, anti-gassy,
Still on would his amperes drive.

CHARLES CHABOT'S GHOST (expert).

"THE ELECTRICIAN" SUPPLEMENT No. 2.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have found an error in equation (*a*):—

$$96 \text{ per cent. conductivity } R = \frac{1003265}{d^2}$$

in Supplement for March 3. It ought to be

$$96 \text{ per cent. conductivity } R = \frac{\cdot 003265}{d^2}$$

for 100 yards.—Yours, &c., W. J. BILLINGS.

12, Bingfield-street, N.

TELEPHONES AND FIRE ALARMS IN RIO DE JANEIRO.

A correspondent writes from Rio de Janeiro, under date Feb. 9, as follows:—

SIR: I noticed in a recent copy of the London *Times* an advertisement of the "Fire Alarm and Signal Company," for doing the service performed in the United States by the so-called "American District Telegraph Companies." It may interest you to know that, even in this remote capital, we have recently established such a company, furnishing messenger, police, fire-alarm, and telephone service, which is meeting with a very satisfactory reception from the Rio public. Its officers are:—C. P. Mackie, president; W. I. Donshea, general superintendent and electrician; and Victor Dias, manager. Mr. Mackie is the attorney in Brazil of Professor Alexander Graham Bell, and the founder of telephony in the Empire—the Government having given him the first concession in 1879—and Mr. Donshea was sent out by the Continental Telephone Company in 1880 to erect the exchanges established under this concession.

TELEPHONIC COMMUNICATION WITH THE "HOUSE."—Mr. Ritchie asked Mr. Shaw-Lefevre the other day in the House of Commons when telephonic communication would be established between the House and the Exchange in the City. The reply was "before long." Mr. Ritchie seemed to think this somewhat vague, and drew Mr. Lefevre's attention to the fact that "any mercantile house in the city could have it (telephonic communication) in twenty-four hours."

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half month ended February 28 were £3,475, as compared with £2,649 in the corresponding period of 1882.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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ANSWERS TO CORRESPONDENTS.

P. Howell.—Thanks for cutting from daily paper. Before giving any opinion on the wonderful results said to have been obtained by Professor Lendstroem, of Helsingfors, we should like to have some more scientific and satisfactory source of information to base our judgment upon. The account may be true, and—it may not.

W. T. F.—Thanks for hints re "Directory." We noticed the ludicrous confusion of the aurora with a lunar rainbow which pervaded the Scotch Press recently. As you say, it was rather odd that the two should be confounded, considering that there was no moon on the night when the aurora appeared.

T. H. S. Hawker.—The "Electric Light Arithmetic" is published by Messrs. Macmillan and Co., Bedford-street, Covent-garden, W.C.

Capitalist (999).—*An answer awaits you here.*

A Constant Subscriber.—We cannot insert letters unless the name and address of the writer is sent, not necessarily for publication, but as a guarantee of good faith.

J. T.—We do not know the exact status of the electrician in the position you mention, but should imagine he ranks with the assistant-engineer—probably as second engineer. The introduction is so modern that no well-defined position has yet been established.

J. G. (Blackburn).—Since answering you in our last issue, we have ascertained that the St. George telephone is made by E. Terraneau, 1, Sherborne-lane, King William-street, E.C.

MR. EDISON'S CANDID OPINION.

America, which claims to be the birthplace of all modern inventions, has, indeed, perfected one which no other country will dare to challenge, and few, it may be hoped, will care to imitate—we mean the art of interviewing. The wielders of this infallible weapon of personal inquisition appear to have inspired such universal terror that, like Mrs. Bond's ducks, their intended victims "come and be killed"—or questioned—as a natural penalty of fame, or flavour, which it would be almost profanity to try to escape. Our comparison fails us here, however, for whereas the ancient dame herself provided all the stuffing to console her doomed flock, stuffing alone is what modern *Mr.* Bond is in search of, and this his human ducks themselves are compelled to supply. Whether they consent to be interviewed or no his report will appear all the same, and they have at length come to consider it best to provide their own stuffing rather than leave it to the imaginative taste of some one who has, perhaps, never seen so much as the tip of their feathers.

Considerations of this kind doubtless weighed with Mr. Edison when he resigned himself to the emissary of the *Herald*. He probably could not evade the ordeal, and if he had done so the alternative would possibly have been the more painful operation of the two. Better say what you would rather not have said than be represented as saying something you never even thought. Thus we have got Mr. Edison's opinion—his candid opinion about some things, and professional opinion about some others besides. So candid, indeed, was the first instalment of his deliverance, which we reprinted in our columns three weeks ago, that some people exclaimed, as of Saul of old, is Edison also among the prophets? And not without reason, for it is an undeniable fact that on this side the Atlantic Mr. Edison's name, ever since the great panic in gas shares, has been associated with that of the Philistines. The association was doubtless undeserved, and the *Herald's* inquisitor is to be thanked for setting this matter right with the English public. In this relation perhaps the concluding words of the final report which we print to-day may be taken both in explanation and excuse. "If," says Mr. Edison in dismissing his interrogator, "If I show that electric lighting is an exceedingly profitable business, when done on a large scale, the public would be dissatisfied with the prices we demand. On the other hand, if I say we can compete with gas, and have to sell the electric light for about the same, then the investing public will put no money into it. So you see"—the interviewer was so to see—"I am in a dilemma about making statements as to cost."

This was Mr. Edison's dilemma, and to some extent, if it had been stated at the outset, perhaps the whole of what followed would have been read with a considerable discount. Still it is candid, and as such is a welcome contribution to the literature of financial dilemmas. Its relegation to the very end of the report enabled us to enjoy the unalloyed satisfaction of perusing all that preceded it. More especially was this the case in regard to the latter portion of the discourse, which dealt chiefly with electrical storing. The great American inventor does not believe in storage batteries. Doubtless he has invented numbers of them; but, if so, they have been successful only in giving his moral senses a rude shock. Storage batteries bring out a man's latent capacity for lying, Mr. Edison declares, and he, probably, agrees with our English correspondent who regards them as a device of the Evil One. About that class of article the interviewer's victim experienced no "dilemma" whatever, the investing public not being then in

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his mind's eye — the "investing public" meaning, apparently, "my stockholders," who, of course, are guiltless of storage batteries.

Upon one other subject also Mr. Edison was almost equally candid. Arc lighting is nearly as great an imposition as electrical storing, and a much greater nuisance. In America it would appear that arc lighting is necessarily effected by means of slack wires slung overhead, and that it does much mischief to something or somebody every day of the week. Morality fails to cope with this enormity, theology alone will touch it:—"If arc light were good for any kind of illumination, it appears to me the Almighty would have given us eyes different from those he has bestowed upon us." This is decisive as touching the eye, whether regarded as an optical or as an æsthetic organ. We are not disposed to quarrel with the statement, though we should prefer to put it differently; but there is no accounting for what one may be tripped into saying while under the influence of a newspaper medium. When a man is made to talk of the community fully realising "the subtlety, pervasiveness, and indeterminableness of the perils arising from vagrant electricity," we feel sure that either he is speaking about matters of which we have no experience, or else that he is parting with his stuffing too liberally. But as we are not famous, and have not yet been interviewed, perhaps we ought not to judge.

On the subject of incandescent lighting Mr. Edison speaks with authority, and what he has to say is both sensible and instructive. Taken with due allowance for the dilemma above referred to, a good deal may be learnt from the report, and it is highly encouraging. In that department of electric lighting Mr. Edison is doing excellent work in this country and on the Continent, where we heartily wish he may achieve all the success he seems to anticipate. What he has said is certainly calculated to reassure at least one class of the investing public, and to reinstate him in the confidence of the European public generally.

THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.*

M. Marcel Deprez has sent to the Academy of Sciences the following translation of the official report of the committee of the Munich Electric Exhibition on the experiments made on and after the 26th September, 1882, concerning the transmission of power by dynamo-electric machines:—

"By means of two dynamo-electric machines (Gramme system) of identically similar make M. Marcel Deprez has transto Munich (over a distance of 57 kilometres) along an ironmitted telegraph wire of 4·5 millimetres diameter the power obtained at Miesbach from a steam engine. The receiving machine placed in the Crystal Palace supplied motive power during eight days to a centrifugal pump feeding a small waterfall of about 2·5 metres in height. The dynamo-electric machines were set in motion for the first time on Sept. 25th, at 7 p.m., and according to the data of M. Datterer, an engineer appointed by the committee, the receiver placed at Munich rotated at a speed of 1,500 revolutions per minute; the brake used to measure the work was loaded with 1·5 kilograms.

"A series of accidents, due to the fact that the machines were made for laboratory experiments and not for practical work, put a stop, at the end of eight days, to the till then entirely satisfactory working of the machines. The hoops which surrounded the ring of one of the machines broke; owing to this, the wires of the ring, ·4 millimetre in diameter, were injured and had to be re-insulated. In the small town far away from Miesbach these repairs could only be carried out under great difficulties, and necessitated much patience and perseverance on the part of M. Marcel Deprez's assistants.

"On the 9th and 10th October, when the Experiment Committee began to take measurements, a speed of only 1,600 revolutions per minute could be reached with the machine that had been repaired at Miesbach; the results obtained were, therefore, far less favourable than they would have been with the normal speed of 2,000 revolutions obtained at first. For some moments only during the measurements could the speed of 2,000 revolutions per minute be obtained, and, again, at the commencement of the experiments one of the brushes of the machine came off, which produced an extra current, and completely destroyed the machine.

"The results obtained under these unfavourable circumstances, under the direction of Professors Dorn, Kittler, Pfeiffer, and Schröter were as follow:—

	Ohms.
Resistance of the line	950·2
Resistance of the machine at Miesbach	453·1
Resistance of the machine at Munich.....	453·4

"The only experiment which need be mentioned lasted five minutes, on the 10th of October, between 12:32 and 12:37. The number of revolutions per minute of the machines was at Miesbach 1,611, and at Munich 752; the current at Miesbach was ·519 ampere, and the electromotive force at Munich 850 volts. Summing up, and taking into account the length of the line, but not losses, we have at Miesbach an electromotive force of 1,343 volts, a total electrical work of 1·13 h.-p., work equal to ·680 h.-p. expended in the circuit in heating, and ·433 h.-p. at disposal for the transmission of a power which is equal to 38·9 per cent. of the total electrical work. The direct estimation of the effective work, undertaken at the same time as the electrical measurements, did not give any exact result; in the first place, the Munich machine had not a sufficiently solid foundation, and part of the work was absorbed by the vibrations of the machine; secondly, the Hefner-Alteneck dynamometer, used at Miesbach, was constructed to measure from 15 h.-p. upwards, and the limits of error of this apparatus were too large for the small power required to be measured. The work obtained at the brake at Munich rose to ·25 h.-p.; to this should be added the work absorbed by the vibrations of the machine. In the place of direct measurements a more exact value of the work expended at Miesbach will be arrived at by reckoning the electrical work expended at Miesbach and the return from the machine at Munich, which was identical with that at Miesbach, a return which can be estimated by the figures given above, taking into account the vibrations.

"As, owing to the numerous accidents indicated above, the results obtained during the measurements made by the Experiment Committee were much less favourable than those made during the first experiments, M. Marcel Deprez has decided to repeat the experiment at Munich, with more solidly made machines*, and then only, we think, can a decisive judgment be given as to the return. Meanwhile, we do not hesitate to proclaim the success of the transmission of power from Miesbach to Munich as in every way an important event in the history of the technical applications of electricity."

M. Marcel Deprez has taken upon himself to consider that the criticisms of his compatriots were not serious, and were inspired by a feeling of envy. We attach no importance to this reproach from the inventor, who has no one to blame but himself for the smallness of his results. The Miesbach-Munich experiments have been impartially judged in other countries besides France, and we know no better way of proving this than by reproducing the opinion of a German paper, the *Centralblatt für Electrotechnik*. Our contemporary says:—

"The author of the report on the Exhibition at Munich,

* Official Report of the Committee of the Munich Electric Exhibition on M. Marcel Deprez's Experiments between Miesbach and Munich, with additional matter. Translated from *L'Electricien* for March 1, 1883.

* Our readers will be aware that the experiment was repeated at Paris the other day, as announced in our notes, *vide Electrician*, March 3, p. 361; Feb. 24, p. 339; Feb. 17, p. 314; and Feb. 10, p. 291.

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after having cited an instance of the transmission of power by means of two Schuckert machines, type T L_4 and T L_5, in which the return was nearly 36 per cent., criticises the Miesbach-Munich experiment. The resistance of the line (two wires of 4·5 millimetres diameter each) was estimated at 950 ohms, and the loss of electricity at 3 per cent. This was owing to the fact that the wire could not be perfectly insulated. The two Gramme machines each had a resistance of 470 ohms; the total resistance of the circuit was, therefore, 1,890 ohms. The speed at Miesbach was 2,200 revolutions per minute, and at the Crystal Palace, Munich, 1,500 revolutions. From this M. Deprez reckoned that the useful effect should exceed 60 per cent., for, according to a known theory, this effect is obtained by the relation between the speeds

$$\frac{1500}{2200} = 68 \text{ per cent., about.}$$

"Now, this theory would not hold, because it supposes the machines perfectly insulated and a line without loss, which has not yet been realised, above all with machines working at high electromotive forces. For instance, in transmitting power at Montceau-les-Mines, the receiver revolved at a quicker rate than the generator, from which it follows that the return ought to have exceeded 100 per cent., a result which even M. Deprez would not care to admit. Further, this theory only gives an approximate value for the return, even with perfectly insulated machines." Further on the author adds, "Dr. Kittler has furnished us with the following figures relating to the Miesbach experiment:—

Current at Munich	·5 ampere.
Electromotive force of machine	850 volts.
Resistance of machine.....	470 ohms.

"The loss of electromotive force inside the machine was, therefore, 470 ohms × ·5 ampere, or 235 volts. We have left 615 volts, from which we get a theoretical effect in kilogrammetres, represented by

$$\frac{C\,E}{9{\cdot}81} = \frac{{\cdot}5 \times 615}{9{\cdot}81} = 31{\cdot}3,$$

whilst M. Deprez asserts that he measured 38 with a Prony brake. If, now, we value at 8 per cent. the loss of electricity due to the magnetic work, to friction, and to Foucault currents, this figure will not be too high, having regard to the speed of 1,500 revolutions per minute; the value given above is reduced to about 28·8. Let us follow out these calculations. The power, expressed in volt-amperes, is, for the generator,

$$E_g = 850 \text{ volts} \times {\cdot}5 \text{ ampere} = 425 \text{ volt-amperes.}$$

"If we remember that the loss on the line was 3 per cent., and the current at Munich ·5 ampere, the current at Miesbach should have been ·515. Let us consider one of the two lines, and take on this line a point the distance of which corresponds to a resistance w. For a variation dw of this resistance, the variation of the power will be:—

$$dE_l = C^2\,dw. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\text{now, } C = {\cdot}5 + \frac{w}{475} \times {\cdot}015. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

In fact, 475 or $\frac{950}{2}$ is the resistance of each of the two lines, since the total resistance of the double line is 950 ohms.

"Integrating, we get

$$E_l = 2\int_{w=0}^{w=475} ({\cdot}5 + \frac{{\cdot}015}{475}\,w)^2\,dw; \quad . \quad . \quad . \quad (3)$$

or,

$$E_l = 2\left[\frac{(·5 + \frac{·015}{475}\,w)^3}{3 \times \frac{·015}{475}}\right]_{w=0}^{w=475}$$

"We thus find

$$E_l = 244{\cdot}9 \text{ volt-amperes.}$$

Now we have only to carry out the calculations as regards the receiver. We see at once that

$$E_r = ({\cdot}515)^2 \times 470 = 124{\cdot}6 \text{ volt-amperes.}$$

From which, then, we get by summing up

$$E_g = 425$$
$$E_l = 244{\cdot}9$$
$$E_r = 124{\cdot}6$$
$$E = 794{\cdot}5 \text{ volt-amperes.}$$

"If, then, we value the loss due to magnetic work, Foucault currents, and in the circuit, at 10 per cent., a figure which the speed of 2,200 revolutions amply justifies, the result should be increased to 874 volt-amperes, or 89·1 kilogrammetres. The ratio then is $\frac{31{\cdot}3}{89{\cdot}1} = 35$ per cent.

"It remains for us to remark that the differences of potential at the terminals of the machines in the Miesbach-Munich experiment are so large that they render very serious accidents both possible and easy."

The author protests against the custom of attributing to M. Marcel Deprez "a theory of the transmission of power to a distance." He affirms that people knew long before him that the useful effect could be considerably increased by using very large resistances. We can *theoretically* obtain, says he, by presupposing a perfectly insulated system, and neglecting the losses due to Foucault currents and other causes, a return of cent. per cent. "Only," he adds, "however well the system may be insulated, the loss increases very rapidly when the resistances and electromotive forces increase, and the danger of working the machines becomes so great that one must be foolhardy to attempt to transmit power under such conditions."

LITERATURE.

Elements of Construction for Electro-magnets. By Count Th. Du Moncel. Translated by Mr. C. J. Wharton. London: E. and F. N. Spon.

We are glad to welcome an English version of this little work. The translation by Mr. C. J. Wharton has been carried out in an able manner, and he has given an opportunity to many of reading a work which otherwise they could not do. In noticing the French edition of the work, we hinted that it was one that all students should read. It is upon a subject that has not proved very attractive to English investigators, and, as the preface of this work says, "further experiments would be of great advantage." The translator has been requested by Count du Moncel "to explain that the experiments undertaken by him in order to determine the ratios of magnetic moment for the standard electro-magnet have not been numerous and varied enough for them to be taken as presenting great exactitude. . . . What, however, may be taken as certain is that electro-magnets constructed and used in accordance with his formulas are employed in the most advantageous manner possible." Now, if there is one thing more than another that the practical workers in electric light apparatus do not know, it is the "formulas," &c., relating to electro-magnets. Henceforth there can be no excuse for ignorance, at any rate so far as the information given in this work extends. The get-up of the book, so far as regards printing and arrangement, should commend itself, and we hope it will meet with the success it deserves.

A Memorial to Morse.—News from Rome states that on Monday last a commemorative stone was placed on the house No. 17 in Via Dei Prefetti to Morse, the telegraphist. The inscription is as follows, translated into English:—"Samuel Finkez Breese Morse inhabited this house from 20th February, 1830, to January, 1831, inventor of the writing electro-magnetic telegraph. He was born at Charlestown 27th April, 1791; died at New York 2nd April, 1872."

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THE BOARD OF TRADE "DRAFT CLAUSES."

In our last issue we gave the memorandum attached to these clauses. The memorandum gives a general idea of the main point aimed at by the clauses. We shall now refer more directly to the clauses themselves.

Preliminary.—These clauses deal with the interpretation of the Act, and define the meaning of "main," "service line," "charging main," distributing main," "general supply," "Schedule A," &c.

Area of Supply (as regards local authorities).—The order is supposed to refer to two areas—a small one A, included in a larger area B. Any part or parts of area B may be added to area A on application of the undertakers any time after the commencement of the order. After two years any fifty owners or occupiers in area B within a quarter mile radius may on application have the area represented by them added to area of supply.

Area of Supply (as regards a company).—These clauses are similar to the foregoing, except that the local authorities have to be duly notified of alterations, &c.

Capital.—Within six months after commencement of order the capital is to be ready, and a deposit made of a certain part of the capital, or otherwise satisfy the Board of Trade. The capital is to be such as seems reasonably sufficient for the supply of area A, and the amount to be deposited is one-half the amount required to execute the works in area A. Failure may lead to the cancelment of the order. The time (six months) may be extended. When the area is extended the capital is to be increased, and a deposit made, within six months. The capital is to be retained by the undertakers for the purpose for which it was originally raised, except by approval of the Board of Trade.

Nature and Mode of Supply.—The "parallel" system is the system to be used, except under approval of the Board of Trade, when the "series," or any other system, may be used. Notice is to be given to local authority two weeks before commencing to supply.

Works.—These clauses refer to erection of distributing boxes of approved construction, to notices, and plans required before interference with streets, &c., to the power local authorities shall have over the work of breaking up the streets, &c., and the perils of default.

Compulsory Work.—The streets specified in area A are to be supplied within two years after commencement of order, and other streets that shall be added to above in the manner specified by the order to be supplied within six months of requisition. Similarly with the streets, &c., in area B. The requisitionists are required to agree to take for a period of three years at least such specified amount of electricity respectively as will in the aggregate at the rate of charge for the time being charged by the undertakers for a supply of electricity from distributing mains to ordinary consumers within the area of supply produce an annual sum amounting to not less than twenty per centum upon the expense of providing and laying down such distributing mains and any other mains which may be necessary for the purpose of connecting such distributing mains with the nearest source of supply.

Maps.—These clauses refer to maps and plans to be supplied, made public, &c.

Regulations as to Supply on the Parallel System.—The supply to be constant at a given pressure (E.M.F.) after six months from commencement of order. Except at times approved by Board of Trade, such intervals being required for testing, &c. The difference in potential not to vary at any point more than 5 per cent. from the standard pressure.

"The standard pressure may be different for different points of any main, and for different hours during the period of supply, but it shall in all cases be within the limits following:—

"In the case of continuous currents it shall not be less than thirty volts, or more than two hundred volts, and

"In the case of alterating currents it shall not be less than fifty volts, or more than one hundred volts, the difference of potential being measured by its maximum value during a complete alternation."

The standard pressure to be fixed for every main and notice given of alteration, which cannot be made without permission. The number of alternations per minute to be not less than 600, or such other number as agreed upon. The supply, to be given to consumer from two poles, up to 50 volts. The undertakers' liabilities end at the poles, and the resistance of the consumers' lines to be such as will not reduce potential more than 2½ per cent.

Testing.—A number of clauses refer to testing, to expenses of testing, &c.

Supply.—These clauses refer to efficiency, compulsory supply, and penalties.

Price.—Charge may be made (except by agreement).

1. By the quantity of energy contained in the supply.
2. By the actual quantity of electricity so supplied, or, unless the Board of Trade from time to time otherwise direct.
3. By the number of hours during which the supply of electricity is actually used by such consumer, and the maximum current with which he has required to be supplied.

Certain notices relating to method of charge adopted must be given, and a maximum price stated, &c.

Meters.—These clauses relate to hire, purchase, connection, testing, &c. of meters.

Regulations as to Safety.—Mains and service lines shall be of a pattern to be approved of by the Board of Trade, and shall be covered with thoroughly waterproof covering, and be contained in pipes or cases of sufficient strength to protect them from injury, and due precautions shall be taken to prevent any insulating material which may be used being rendered plastic or being otherwise injured by the action of external heat. The insulation to be of a durable character, with a resistance of not less than 1,000 ohms per mile run, or such other amount as may from time to time be described by any regulations of the Board of Trade. No conductor in any part of any circuit shall be connected with earth unless such connection is sanctioned by the Board of Trade. The current through any service line shall not exceed —— amperes per square inch of section of a pure copper wire of equal conductivity. The supply of electricity to each house shall be capable of being turned off at some point outside the building. In each conductor of each service line shall be inserted a safety fuse or other safety connection of a pattern to be approved by the Board of Trade. Such fuse or connection shall be situated in a distributing box or at some other point in the service line which is easily accessible, and shall be of such a nature as to cut off the supply when the current through such conductor exceeds by more than 100 per cent. (or such other smaller proportion as the undertakers may think fit) the maximum current which such service line is intended to supply. The positive and negative poles upon the premises of the consumer shall be at a distance of not less than 3in., and the terminals shall be of a construction and pattern to be approved of by the Board of Trade, and no portion of any service line which may be upon the premises of any consumer shall contain any joint between the point at which it enters upon the said premises and the said poles. Where the maximum current given to any consumer upon the parallel system exceeds fifty amperes, the supply shall be divided and given at more than one pair of poles, so that the maximum current at each pair of poles shall not exceed fifty amperes except in such cases and under such conditions as may be approved of by the Board of Trade. Where the difference of potential between any point of any main or electric line used by the undertakers and the earth, or between such point and any other point upon the same circuit exceeds 200 volts, such precaution shall be taken by the undertakers as may from time to time be prescribed by the Board of Trade to prevent such main or electric line becoming electrically connected with or leaking into any main or electric line through which electricity passes at a different potential. Where the difference of potential between any point of any charging main and the earth or between such point and any other point upon the same circuit exceeds two hundred volts, all distributing mains connected therewith shall be fitted with such appliances and apparatus of such pattern and construction as may be from time to time prescribed or approved of by the Board of Trade for the purpose of ensuring that such mains shall be effectively disconnected and kept disconnected from such batteries during the hours of charging. No portion of any electric line which may be placed by the undertakers above ground, and which is not enclosed within any distributing box or building, shall be at a potential differing from that of the earth by more than two hundred volts. Where any portions of any electric lines belonging to the undertakers are exposed in such a position as to be liable to be struck by lightning, they shall be efficiently protected by lightning dischargers of such pattern and contruction as may be from time to time prescribed or approved by the Board of Trade. The difference of potential at corresponding points of the positive and negative conductors used as distributing mains or service lines shall not at any time exceed two hundred volts, and no portion of any such conductor shall be at a potential differing from that of the earth by more than such quantity. The difference of potential at any two points of a charging main shall not exceed four thousand

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volts, and no portion of any such main shall be at a potential differing from that of the earth by more than such quantity.

Provided always, that if the undertakers at any time desire to supply electricity by agreement at a high tension for the purpose of arc lighting or for any other purpose, the Board of Trade, if they think fit, may relieve the undertakers from all or any of the obligations by this section imposed upon them, and may substitute such other regulations to be observed by the undertakers in relation to such supply as they may think expedient; and all regulations so substituted shall be observed by the undertakers, and shall, for all purposes of enforcement or otherwise, be deemed to have been inserted in this section in lieu of the regulations for which the same are substituted.

EDISON'S VIEWS ON ELECTRIC LIGHTING.*

After remarking on the *Herald* installation, Mr. Edison said:

"It is the lighting simply from an isolated plant—not like lighting from a central plant which supplies a large area with light, like a gas company. What I started to do was to light a whole city, furnish electric light as gas is furnished, and collect and make money on bills running as low as 75 cents a month. In the district we are now lighting we have several consumers whose bills do not amount to more than 1dol. 50c. a month. Our plant at 237, Pearl-street is one of the typical stations by which we propose to light cities. Such stations can be multiplied indefinitely, so that we can engage to light the largest as well as the smallest cities in the world. At this time 289 stores are taking light regularly from us on meter. We have commenced to connect more stores with our mains, and expect to have, by the middle of February, 550 stores lighted from that station. In most of the stores now lighted by us gas has been entirely cut off. Many, indeed, have not been using gas for the past four months. In fact, they depend entirely upon us for their light, and we do not fail them. At first we placed temporary fixtures on their gas chandeliers, but are now gradually changing them over to our electric chandeliers. This looks like permanency, does it not? Well, that is just what it is. We have come to stay. We have 19 miles of street mains and four miles of service pipes, and all our wires are underground. They are carried in iron pipes of twice the thickness of ordinary iron pipes, and coated with asphalte. If, in the course of years, these pipes should rust through, it would not harm us so far as using the wires is concerned, for our wires or rods have a quarter of an inch insulation over them in the pipes."

"How about regulating the supply of electricity according to the needs of consumers?"

"Persons outside who do not understand our system are trying, I know, to make people believe that if we are running, and all the lamps in the circuit are put out, there is at once a loss—a waste of energy. According to our system, if all the lamps in the circuit were put out, the automatic cut-off of the engines causes less steam to be admitted to the cylinder, but sufficient to keep it running. Suppose, for example, a single engine was running and its dynamo connected to the mains and no lamps were being used. The only power required would be to keep the engine running without doing work. If, now, eight lamps are turned on by some consumer, the automatic cut-off of the engine will admit more steam to the cylinder and the engine will give one horse-power in work; if 80 lamps are now connected, more steam is admitted to the cylinder, and the engine gives 10 horse-power; and so on up to the capacity of the engine. The steam dynamos at our station, when working economically, give 185 horse-power. We have six of them. Up to 1,400 lights we use a single steam dynamo. When the consumption exceeds this number of lights we add another dynamo and engine. When the consumption reaches 2,800 lights another is added, and so on—thus each steam engine and dynamo is worked at its most economical point; the number of engines working depend upon the consumption; our greatest consumption is between 5 and 6 p.m., when five engines can be put on, leaving one for a spare, which can instantly be connected to the mains in case of accident to any of the others, but even if the spare engines should become disabled four steam dynamos will carry the load, but not with the same economy as if five were used. Before 5 and after 6 p.m. the consumption is greatly lessened, and there are two or three spare steam dynamos. What I mean by a steam dynamo is where the engine is connected direct to the dynamo without the intervention of pulleys or belts. We have a relay of boilers upon which we can depend to give us all the power needed and meet every emergency. You will understand that we have a large number of consumers, and know from general average pretty accurately what they will demand from us. We can, therefore, tell beforehand what will be the consumption during different hours of the day, which varies with circumstances. If the morning be foggy or dark we start up with two or three boilers. We also have an indicator to tell how much power is required, and, as the load increases, we add more boilers, just as the case with the steam dynamo, disconnecting them as the load diminishes. We started our engine on September 4 last, and since that time the current has never been off the main for a second, night or day."

"What do you think of lighting by the electric arc?"

At this question Mr. Edison smiled contemptuously. He said:—"The arc people get a little place, with a boiler, engine, and a dynamo or two, and then they string their wires like clothes lines, overhead in various directions, connecting with a few lamps here and there, and call that a system of electric lighting. These wires generally break down six or eight times a year, when all the lights go out. No attempt is made toward permanency. They have no means of ascertaining how much electricity is used, but guess at it and trust to luck. That [with emphasis] is not electric lighting. It is nothing but boys' play—a temporary makeshift—an excuse for the creation of a stock corporation with an unknown quantity or possibility as a bait. This stringing wires over houses and along a lot of poles in large cities has a serious side, which is well set forth in an editorial in the *Scientific American* of January 13, under the heading of 'Perils from Suspended Electric Wires.' Let me give you a few extracts:—'The promoters of electric lighting confidently promised at first that the new illuminant would insure complete immunity from the peculiar fire risks and dangers to life and health incident to the use of gas. The promise has been fulfilled; but, unexpectedly, the use of electricity for public lighting has developed a variety of public perils as numerous and serious as any due to illuminating gas, and far more subtle. [This, of course, refers to the arc lighting.] Scarcely a day passes without some new and surprising development of this character. . . . Until the introduction of suspended conductors for the larger current employed in electric lighting, the multitudinous telegraph and telephone wires were no more than harmless offenders against æsthetic propriety. Crossed by electric light conductors, they at once become the means of ever impending fire hazard; for the current diverted by the slightest contact with an electric light conductor suffices to heat the coils of telephones and telegraphic instruments to such a degree as to destroy them, and at the same time set fire to any combustible matter near at hand. But this is not the only peril incident to such contacts. An officer of the fire department of this city reports that, during a recent fire, the assistant foreman of a fire company received a severe shock when he went to re-case the key of a fire-alarm box near the scene of the fire. The inference was that the fire telegraph wire had been accidentally crossed by an electric light wire, and that, had the pavement been damp on which the fireman stood, so as to make good 'ground,' the current passing through his body might have killed him on the spot. Only a few days before, an accidental contact of an electric light wire with a fire service telegraph wire resulted in the destruction of the electro-magnets in a dozen fire-alarm boxes in Nassau, Liberty, Fulton, Beekman, Greenwich, and Hudson-streets. By spoiling the means of instant communication with the fire service, in case a fire should break out, an accident of this nature is obviously a very serious affair. And quite as undesirable as the interruption of the fire alarm service is the development of a feeling among firemen and citizens generally that the legitimate use of an alarm box involves a peril that may be as sudden and deadly as a stroke of lightning. Telegraphic switch-boards and telephonic instruments are similarly made more or less hazardous to use by the same misdirection of electric light currents. Still more recently, at a fire in Fourteenth-street, some broken telegraph wires in front of the building fell across an electric light wire, and became entangled with the firemen's hose. It is probable that the heated telegraph wires burnt through the insulating cover of the electric light wire, so as to establish contact. At any rate, when a fireman went to free the hose from the wires he received a severe shock. Enough of the current of the electric light wire had been diverted through the broken telegraph wires to the ground to make it unpleasant if not dangerous to handle them. . . . With the rapid extension of electric lighting by means of arc lights, the hazard of life and property arising from misdirected currents has suddenly become one of the most serious as well as alarming of city evils. And it is certain that were the community to fully realise the subtlety, pervasiveness, and indeterminableness of the perils arising from vagrant electricity, as it would if each diversion of an electric light current were accompanied, as the not more dangerous light-

* Continuation of a Reprint from the *Boston* (U.S.) *Sunday Herald*, *vide Electrician* for Feb. 17, p. 329.

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ning stroke is, by a peal of thunder, there would arise a speedy and positive demand for the adoption of safer modes of distributing this useful but treacherous agent.' There you have the testimony of a journal which has no interest in any system of electric lighting. Here let me say that the arc light people measure their light by the French method, and claim 2,000 candles, when, as gas is measured, it should only be 500; but, in reality, even if we measure in every direction, it would be only 280 candles. But they find they are losing money, and bring their carbons so near together that they are, in many cases, giving only 100 candles."

"But is not the arc light well adapted for outside illumination?"

"Not by any means; it is not good for any kind of illumination. If it was, it appears to me the Almighty would give us eyes different from those he has bestowed upon us. The arc light is unreliable, to begin with. Its very nature makes it so. It has no diffusive power. Aqueous vapour, as is well known, will absorb the blue, green, and violet rays which make up a white light. It is only the red and yellow rays that will pass through it with facility; of these rays the arc light possesses very little. In a dense fog you cannot, therefore, but just see an arc light, but a gas lamp alongside it can be discerned easily on account of the great volume of red and yellow rays. I wonder your people in Boston have so many arc lights. If the ruse is continued a few years longer the people's eyes must suffer. In Paris, in the Jablochkoff works all the workmen are troubled with sore eyes. It produces a new kind of disease of the eye, the name of which I cannot now recall. Under the influence of such a light, if you watch the contraction and expansion of the eye from the alternate brilliancy or quick alternation to a low power of illumination, you will see what I mean. It is hard to read by gaslight, the flickering of which contracts and expands the pupil of the eye, irritating the visual organ in a most painful manner sometimes. Now, kerosene oil gives a steady light, and it is the same with our incandescent light. I have looked at an arc light, then went into a room lighted by gas, shut my eyes for a moment, opened them, and the pupils expanded a quarter of an inch. Of course some eyes will contract and expand more than others. You can try it yourself by using a small hand mirror and looking on a gaslight and then turning your eyes on the glass, when you can plainly note the contraction and expansion of the pupils, the changes being rapid and marvellous. A light can be very bright, but as long as it is steady it will not change the size of the pupil. Gaslight can never be steady, any more than the arc light. The pressure on gas is so small that the shutting off or turning on of light—which is occurring at all times in a city—causes constant vibrations. Even a gas engine, fed from the general supply, where the consumption is intermittent, produces vibrations all around among the gaslights. Lighting a theatre suddenly will produce a wave of low pressure all around the vicinity, and several oscillations will take place until the wave dies out. A thousand such incidents occur to produce changes in pressure and consequent flickering."

"Will not the incandescent lights act in the same manner if there is a sudden and considerable demand made upon their source of supply?"

"They will respond to such a demand, it is true, but it is only for an instant, and no waves will occur, while, in the case of gas, there is depression, which may last a minute and a half, and there may, in this time, be produced from 20 to 30 oscillations. It is a very difficult thing to distribute gas evenly, and ten times as hard to distribute electricity; but, so far in our district, we have our pressure far more even than the gas men."

"By the way, Mr. Edison, have you ever tried gas as a fuel; for, of course, the matter of economy in this direction is a most important one?"

"I have made, at Menlo Park, during some eight months, many experiments on fuels. Among other things I tried gas, which I made on the spot, and put under the boilers. Gas is a very nice fuel, but not so cheap as from coal direct. It required more ability to produce and use it than coal, and brains now cost more than coal. Perhaps by and by, when brains are cheap and coal scarce, we may find it to our account to use gas as fuel. But, so far, coal is the cheapest. We use a 3dol. coal at our station—peat and dust."

"You, of course, are confident of the success of your system?"

"I started in 1878 to subdivide the electric light and displace gas. The first I accomplished; as to the latter a great deal of talking has been done, but, nevertheless, we are going to do it. It is gradually being done by distributing it in exactly the same way that gas is distributed—that is, from large central stations, with main pipes running through the streets, tapped wherever required, and run into the cellars of houses, the electricity measured to consumers with metres, and that is the only way it will ever be done. You cannot place in the hands of the public any mechanism of a complicated character, and have it prove a success. It must be under the control of those who understand the business. The public have got to pay their bills, and that is all we ask of them. We now know exactly what incandescent lighting costs at the present time. The cost of production and investment required for a given output is being diminished continually. If we start a station in Boston we shall sell light at the same price as we do in New York, which is about the price of gas."

"Can you make money at it?"

"Yes, we can, and are doing it in the present state of the act, and, in addition, the margin for improvement is infinitely greater than it is with gas. In 1878 people said the subdivision of the electric light was impracticable—could not be done. Now we are doing it upon a commercial scale, and are not losing money. If this has been accomplished in four years, why cannot still further improvements be made to the end of materially reducing the cost of production? Of course they can, and if, by such improvements, we can produce the electric light at less cost than at present the public will get one-half the benefit ('if our stockholders feel like it') and we the other half. As it is we, do not find that it is even necessary to come down to the exact level of gas, as people are willing to pay more for our light than gaslight. I consider from experience gained thus far that a unit of light by electricity has a commercial value 33 per cent. above that of gas, as gas is above kerosene, and, if we desired, we can get 33 per cent. more for the same unit of light over and above gas, as people are willing to pay more for the same amount, but of a better quality. They will pay 2dols. 25c. for gas for the same amount of light they can get in kerosene for 60c. Men will sometimes get excited over their gas bills, put out the gas and use kerosene; but they will inevitably return to gas. We have had an experience of that kind. One of our customers thought he was paying too much for his light, and we cut him off; but in two or three days he came to us and wanted it put back. Following the subject of the relative cost of gas and electricity we have made photometrical measurements of gas under every variety of conditions in New York city, and find that the average amount of standard candles of light obtained in practice from the consumption of 1,000 cubic feet of gas is 2,000 standard candles. Buy 1,000 cubic feet of the gas sold by the Boston Gas Light Company, burn it in the burners that are used in practice, and you will not get more than 2,000 standard candles. At the city gas testing department, with a definite pressure, a new and perfect burner, made expressly for the quality of gas, and nursed by a skilled expert, 1,000 cubic feet of Boston gas would give 3,200 standard candles. But, in actual practice, there are burners of all kinds, old and new. The pressure of the gas on the mains varies in every part of the city; it is, besides, constantly altering in different localities by varying consumption; hence, if new burners were used, the variations of pressure would diminish the amount of light, and the burners, after a few weeks' use, would, by deposition of matter within the slit of the burners in different degrees, give all kinds of candle power. I will give you an instance. About a year ago you will remember that I kept promising, through the newspapers, that the large central station in New York would be started at such and such a time (these many promises, by the way, were made more with a view to keep up the courage of my stockholders, who naturally want to get rich faster than the nature of things will permit), and, having failed to start upon several of the dates named, the gas companies operating in the district in which our mains were laid concluded that on one of my dates I would certainly start, whereupon we sent emissaries around and provided all of their consumers with new burners free of charge, to the end that a more favourable comparison could be made. These burners, from tests made by me at several points, gave 2,700 candles per 1,000ft. of gas consumed. The station was not started until two months after this had been done. The burners had so deteriorated during this interval, that three days after starting our station the same burner only gave 2,300 standard candles, and, I presume, by this time they do not give more than 2,000 candles. This is a thing that can easily be verified. It is not a difficult matter to determine the relative cost of both kinds of light at your *Herald* Office. Knowing the cost of gas, then make a rough mental calculation what the electric light would cost from a great central plant supplying 50,000 lights. Some people are continually chattering about the cost of electric lighting, that it cannot be made as cheap as gas, &c. If, in answer to these people, I show that it is possible, and that it is an exceedingly profitable business when done on a large scale, the public would be dissatisfied to pay the price we sell it for. On the other hand, if I say we can just compete with gas, and have to sell it for about the same, then the investing public will put no money into it. So, you see, I am in a dilemma about making statements as to cost."

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THE INSTITUTION OF CIVIL ENGINEERS.

The second of the series of six lectures on the applications of electricity was delivered on Thursday evening, the 1st of March, by Sir Frederick Bramwell, F.R.S., V.P. Inst. C.E., the subject being "Telephones." The following is an abstract of the lecture:—

Prior to the invention of the telephone, by making and breaking circuit at the transmitting station sounds had been produced at the receiving station—such as the striking of bells, or the vibration of a Morse sounder—but these were independent of sound at the transmitting station, and they varied according to the implement used at the receiving station, and were and are used for purposes of audible telegraphy. Also, prior to the invention of the telephone, it was possible to reproduce at the receiving station, say by a tuning-fork, the vibrations of which break and make contact, the same note produced by a similar tuning-fork at the transmitting station; and in this case there was a reproduction at the receiving station of the sound at the transmitting station. But the only thing that was ensured was the repetition of the same note—there was no reproduction of the same sound. For example, the note might have been uttered by a violin string, by a tuning-fork, or by a clarionet at the transmitting station; at the receiving station, however, nothing would be given forth but the note of the particular tuning-fork, or other vibrating implement, which was in accord with the number of the vibrations transmitted in a given time. All these modes were due to the variations of the current caused by break and make in the circuit, and were therefore abrupt. The best result obtained with such an agency was in the machine of Reis, who, in 1862, reproduced tones, and it is said some words were heard. That machine received no development, and telephony lay dormant for fourteen years, until the invention of Professor Graham Bell, patented in this country in December, 1876. In 1874 Mr. William Henry Barlow, F.R.S., Past-President Inst. C.E., turned his attention to the recording of the vibrations produced by speech. He effected this by means of an instrument called a logograph. This was communicated to the Royal Society, and exhibited in operation there. By its agency there was depicted on a travelling band of paper the motions derived from the vibration of a membrane under the influence of speech; but had the results been known, they would, probably, have deterred an inventor seeking to produce a telephone, as it appeared the vibrations were not always the same for the same syllable, but varied with the speaker and from the circumstances. Professor Graham Bell graphically represented the variations in the electric current, either direct or reversed, caused by break and make, and showed that these were too abrupt for his purpose—namely, the reproduction of articulate speech. He proposed to attain the object sought by having the circuit always closed, and by causing rises and falls, or reversals, as the case might be, of electricity which should be made gradually, instead of abruptly, as before. The simplest mode in which he attained this end was in one of the original forms of the Bell Transmitter or receiver (for the instrument was capable of fulfilling either function) by placing an iron or a steel plate in the neighbourhood of a permanent magnet surrounded by a coil of insulated wire, so that on the plate being set into vibration by the voice it should induce, in the coil, reversed currents of electricity which could travel along the wire in prolongation of the coil to the coil of the similar instrument at the receiving station, thereby varying the power of the magnet at that station and setting up vibrations in the corresponding iron disc. This disc, acting upon the air, gave to it vibrations similar to those which had put the first disc into motion, and, in that way, a reproduction of the original sound (as Professor Bell said a *fac simile*) was obtained. Other modes were employed by him, such as the use of a battery in the line-wire, and best of all, the use of two local batteries to send the current to a primary coil round a core, the line-wire being connected with secondary coils acting by induced electricity. As transmitters these instruments were necessarily somewhat feeble, since the whole of the electricity in the first of the three cases mentioned, and what might be called the operative electricity in the other two cases, had to be derived from the microscopic movements of the disc, under the influence of the sound-waves produced by the speaker.

Edison's phonograph was exhibited, in order to show that a disc, when caused to vibrate under speech, could by a central needle impress those vibrations on tin foil, and that on the tin foil being caused to traverse under the needle, the reproduction on the disc of those vibrations caused it to repeat the speech which had originally set the disc into motion. This was appealed to as a convincing proof that a disc, when mechanically vibrated in a manner corresponding to the vibrations which had been imparted to it by speech, was sufficient, wholly irrespective of any electrical agency, to impress upon the air the needful vibrations to reproduce speech.

Edison then devised a transmitter, wherein the disc need not be metallic, but might be mica, and its vibrations were caused to operate upon a small block of carbon, which carbon was introduced in the circuit of a battery. It was thus found that the almost inappreciable variation in pressure due to the vibration of the disc was sufficient, for some not very well understood reason, to alter the conducting power of the carbon, and to cause varying currents to be transmitted along the line-wire to the Bell receiver at the opposite end. At the present day the universal transmitting instrument for commercial purposes is the carbon transmitter of Edison or some modification thereof.

Professor Hughes's microphone was next alluded to, and it was stated how by its means the most minute sounds were rendered audible, and how, from the delicacy of the instrument, it was applicable to many scientific purposes.

Edison's chalk receiver was subsequently explained. Prior to Edison's time, it had been known that the friction of certain surfaces varied with the electric current passing through them, notably under such circumstances, the friction of the human tissue. Among other appropriate substances prepared chalk was one, and it was shown how Edison availed himself of this. By attaching a stem to the centre of the disc, and pressing this stem, by means of an adjustable pressure, upon the periphery of a chalk cylinder, a current of electricity passed from the centre of the cylinder through the stem. Upon the cylinder being turned by hand the friction on the stem caused it to move the centre of the disc—its edge being fixed—to a definite position depending on the friction, and on the rigidity of the disc; but, on a variation in the current, the change produced thereby in the friction caused the stem either to be drawn in further or to yield to the elasticity of the disc and to allow it to be moved backwards. In this manner vibrations were set up in the disc corresponding with the vibrations of the transmitter that had sent the varying electrical currents. As in the case of this receiver the power was derived, not from the electricity, but from the hand of the operator turning the chalk cylinder, very considerable loudness was obtained, so that the utterances of the receiver were audible in a large room.

Mr. Shelford Bidwell having been good enough to lend a photophone, that beautiful invention of Professor Graham Bell was explained. Mr. Bidwell showed how, by speaking to a disc, the front being a mirror, on which a powerful light was directed, that light could be reflected on to a selenium cell, and as the disc vibrated under the influence of the voice the light playing on the selenium cell varied. Selenium was a material the conductivity of which changed with the amount of light upon it. It was, therefore, possible in this manner to cause a Bell receiver to speak, and reproduce the speech which had been uttered to the mirror disc. It was pointed out that, in this manner, there was no need of a wire connection between the transmitter and the receiver, the passage of a beam of light being all that was required.

Reference was then made to the various purposes to which the telephone might be put, and to the exchange system and the necessary apparatus for receiving the calls and making the connections between the different subscribers to the exchange. Amongst special uses, a very interesting one was shown—that of the application of telephony to the diver's helmet. Thanks to the kindness of the captain of H.M.S. "Vernon" and of Mr. Gorman, a helmet with the whole of the apparatus was exhibited. It was shown how the application of the telephone in no way introduced any complication, as the single wire needed was in the middle of the old call rope, the return being made by the water itself. Thus, if the telephone went wrong, the diver was left without additional apparatus of any kind to encumber him, and yet with all the resources that he would have had in the absence of the telephone.

It was stated that the development of the telephone had been far more rapid in America than in England. As an instance, it was mentioned that in the City of Washington, with a population of about 120,000 white persons, as many as 800 telephones were used. Then, a return, circulated that very day by the United Telephone Company, was read, showing that on the 28th of February, in the year 1881, there were, independent of private lines, 845 subscribers to the London Exchange; that on the same day in 1882 the number had increased to 1,505—or an addition of 660; and on the 28th of February this year the number was 2,541, or an addition of 1,036; and that contemporaneously with these increases the use of the telephone by each subscriber had augmented, until it now reached more than 7½ calls per day for each subscriber, which, at a cost of £20 a year, represented only twopence a call; or, bearing in mind that each

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call involved a return message, it only amounted to one penny for the message sent each way.

The lecturer was fortunate in having the assistance of Mr. E. H. Johnson, who had been so much associated with Mr. Edison in carrying out many of his inventions, and who was kind enough to put into work both the phonograph and the chalk receiver.

The third lecture of the series will be on "The Electrical Transmission and Storage of Power," by Dr. C. William Siemens, F.R.S., M. Inst. C.E. This is to be delivered on the 15th of March.

ELECTRIC LIGHTING AND LOCOMOTION.*

(CONCLUDED FROM PAGE 357.)

[In that portion of Prof. Ayrton's lecture which we printed in our issue of Feb. 24 reference was made to an obliquely coiled dynamo which Prof. Perry and the lecturer had designed. We now give illustrations, showing the mode of winding the armature of this dynamo, as well as other details, which are sufficiently explained by the three figures which follow.]

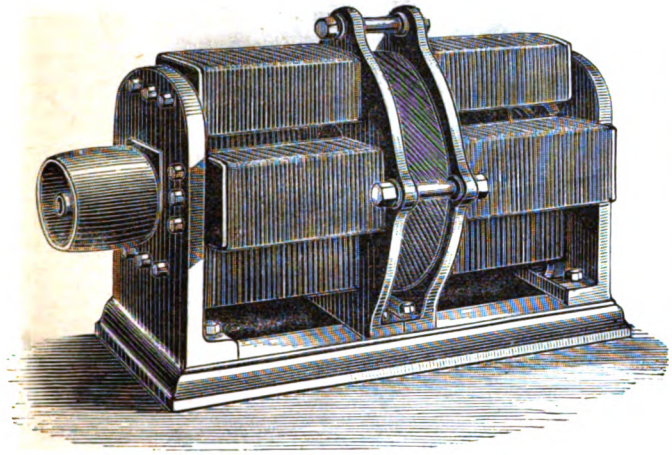

FIG. 1.—Ayrton and Perry's Oblique Coiled Dynamo.

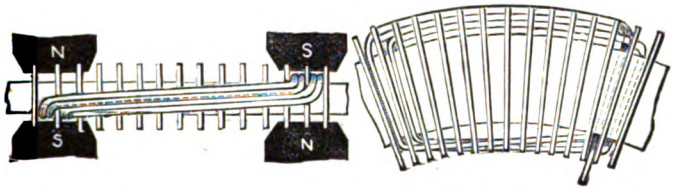

FIG. 2.—Plan and Elevation of portion of Armature

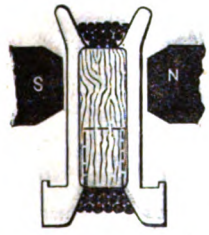

FIG. 3.—Section of Armature of Oblique Coiled Dynamo.

Two of the methods that have been devised to regulate the supply of electric energy in proportion to the demand appear to me to have all the defects of the automatic regulator at the gasworks in that they are far too sluggish. In the one plan, when the dynamo is producing less than the required amount of electric energy, so that in the parallel system the electromotive force between the main leads falls below the normal amount, or the current in the series system becomes less than the normal current, an electro-magnet is partially demagnetised, which has the effect of opening the throttle valve of the steam engine, or altering the expansion, so that the steam engine, and, therefore, the generator-dynamo, goes more quickly than before. But as it is quite possible to start a motor, or turn on a lamp, or many lamps, somewhere in the circuit instantaneously, whereas it is impossible to suddenly either increase or diminish the speed of an engine and dynamo, the regulation in such a system is always considerably behind the change calling it forth,

In the second system no alteration is made either in the speed of the engine or dynamo, but a resistance is withdrawn from the main circuit or from the circuit of the exciting magnets of the dynamo; when the supply of electric energy falls below the demand, the dynamo, in fact, is made more powerful. [A large design showing one of the plans employed by Edison for effecting this latter object was exhibited.]

This plan of introducing a resistance is far better than the former, by which it was attempted to slow both the driving engine and dynamo, in that there is no large mass like that of the engine, the speed of which has to be suddenly changed; but it has the disadvantage that at any rate some mechanism has to be set in motion to vary the resistance, and this requires some time to effect, not to mention the difficulty of producing perfect dead-beatness in the mechanism to avoid oscillations. Also, if the exciting magnets of a dynamo are very powerful, as in the Edison machine, their strength cannot be suddenly altered by altering the strength of the current flowing round them. Hence, with this plan, again, there is a fear that the regulation may be behind the change calling it forth.

There exists, however, a third and totally different plan for governing dynamos, not depending at all on the motion of any electro-magnet, nor on anything like a mechanical governor, and which is extremely quick in its action. This third plan has been carried out in three totally distinct ways—1st, by Brush, in America; 2nd, by Deprez, in France; 3rd, by Professor Perry and myself, in England.

I have said that in any machine for the mechanical production of an electric current a coil of wire must be moved rapidly in a magnetic field. Now, there are four distinct ways in which the magnetic field may be produced—1st, by a permanent magnet, in which case the generator is a "magneto-electric machine;" 2nd, by an electro-magnet, the current flowing round which is produced by an auxiliary battery or electric generator (such a machine is said to be "separately excited); 3rd, by an electro-magnet, the current flowing round which is the main current produced by the generator itself, in which case the generator is a "series or single-circuit dynamo." And lastly, only a portion of the current generated in the moving coil may pass round the electro-magnet, in which case the generator is called a "shunt dynamo." In the two first cases, the magneto-electric machine and separately excited generator, the electromotive force depends almost entirely on the speed of motion and only slightly on the current; while in the third case it increases, and in the fourth case diminishes, with the strength of the current produced when the speed of motion remains constant.

The method employed by Brush consists in doubly winding the exciting magnets, so that the machine is both a series and a shunt dynamo. Deprez also doubly winds the exciting magnets, so that his machine partly magnetises itself, and partly is separately excited from an auxiliary dynamo. In which case two magnetic fields helping one another are produced by this double winding, and dynamos as ordinarily constructed cannot be thus governed without being rewound; further, if a number of dynamos in the same building are to be governed, each must be doubly wound in the manner described.

(The lecturer here described Ayrton and Perry's mode of joining up so as to obtain constant difference of potentials between the mains.)

When we had the lamp and motor in parallel, why was it that the lamp burnt well when the motor was stopped, but only gave a feeble light when the motor was running? Was this due to the electromotive force of the battery diminishing when the motor ran? No; the electromotive force is constant, but a certain portion of this electromotive force is always being employed in sending the current through the battery itself, and the remainder only is available for sending the current through the external resistance, and the proportion of the latter to the whole electromotive force diminishes as the current sent by the particular battery increases.

As long, however, as the resistance of the battery is small compared with that of the external resistance, the current passing through any one lamp is not affected by the number of lamps put in parallel. For example, these two Grove cells make this one lamp glow, so also do they equally well make these three lamps in parallel, because in each case the resistance of the battery is less than that of the lamps. But if I put 20 such lamps in parallel, you observe only a faint glimmer. [Experiment shown.] Let me now repeat this experiment, using in the place of two Grove cells two Faure-Sellon-Volckmar accumulators, and what is the result? You observe I can increase the number of the lamps from one up to 20 in parallel without seriously diminishing the glow in any one of them. [Experiment shown.] If, then, we could have a magneto-electric machine with an armature possessing an excessively small resistance, but producing a sufficiently high electromotive force, one lamp or a hundred could be lighted equally well if the speed of the machine were kept constant—that is to say, the supply of power necessary to keep the speed constant would always be exactly equal to the demand for power necessary to keep any number of lamps equally bright. But, in the absence of such extremely small resistance magneto machines, we must resort to some device to cause one lamp or a hundred lamps to burn equally bright, and the device Professor Perry and I have adopted for the multiple arc system is the combination of a large magneto machine, or main shunt dynamo, which does all the external work, and a small regulating series dynamo which does all the internal work—that is, sends the current through the dynamos itself. In fact, our combination produces the same result as if the resistance of the armature of the larger machine could be made nought without diminishing the electromotive force it can generate.

The speed of the magneto machine or of the main shunt dynamo merely depends on the type of lamp employed, and is such that if it were used *alone* with only one or two lamps, it would produce a difference of potentials between the brushes just sufficient to make the lamps glow properly. The speed of the small governing series dynamo has nothing to do with the lamps; in fact, must be kept quite the same whatever kind of lamps or number of them are employed. The speed of this governing dynamo is what is called the "critical" speed for an external resistance equal to that possessed by the armature of the main magneto or dynamo machine, and which means the speed a little below which the series dynamo would give an extremely small current and a little above which it would give a very great current, if the external resistance were kept constant and equal to that of the armature of the main dynamo—that is, if the external circuit were short-circuited.

This critical speed, which was first suggested by Sir Wm. Thomson, in the earliest days of dynamo machines, in a paper called "An Electrical Paradox," is of the greatest importance to us electrical engineers for governing, since it enables a very slight change of speed to convert a very weak generator into an enormously powerful one, corresponding in steam

* Lecture I., delivered by Professor Ayrton, F.R.S., at the London Institution, February 22, 1883.

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engines with a very great change in the supply of steam for an extremely small change in the speed, the result aimed at in any good loaded governor for a steam engine.

(The lecturer here described Ayrton and Perry's mode of connecting up for a constant current.)

In the admirable Cantor lectures recently given at the Society of Arts by Professor Silvanus Thompson, the methods employed by Professor Perry and myself for regulating difference of potentials and current were gone into far more fully than I can do here in a popular lecture, and as doubtless many among you who are electrically inclined will read those lectures with interest, Professor Thompson will, I am sure, pardon my giving you a word of warning about the diagrams accompanying his description, since, from some oversight, probably on the draughtsman's part, they do not represent correctly the relative dimensions of our main and regulating machines in each case. This, however, I have endeavoured to do in the symbolical diagrams shown at this lecture.

Up to the present time whenever it has been necessary to convert electric energy into mechanical energy, use has been made of a dynamo worked backwards. But a dynamo is designed for converting mechanical energy

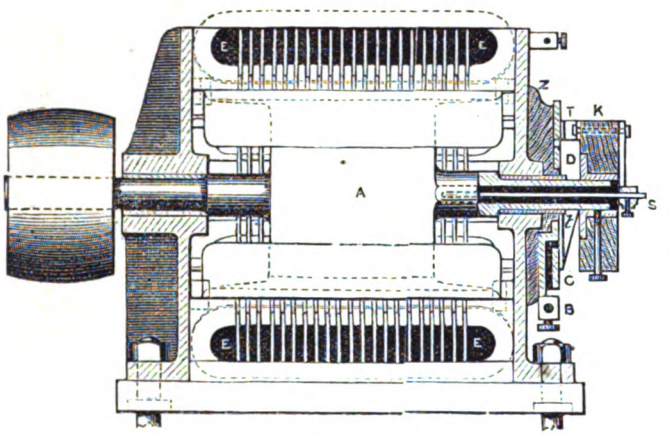

FIG. 4.—Ayrton and Perry's Electro-motor. Longitudinal Section.

into electrical energy, and not to do the converse, therefore, although every dynamo will act as a motor, Professor Perry and myself have come to the conclusion that for its weight it is by no means the most powerful motor that can be designed. In a dynamo there is, as you all know, a large electro-magnet, which produces what is termed the exciting field and a moving armature, the current flowing through which produces another magnetic field, which in all dynamos tends to weaken the first and important magnetic field. Hence the best dynamos have been so designed that while the exciting electro-magnets produce a very strong field, the armature shall produce a very weak field.

The result has been arrived at partly by making the armature of a dynamo small compared with the exciting electro-magnets, and partly by giving it a squat form; but, in a motor, we have concluded from certain theoretical and practical considerations that, on the contrary, the strengths of the two magnetic fields produced by the exciting magnets and by the armature should be equal, and since the armature, from its shape, is necessarily rather a weak magnet, whereas the field or exciting magnet, from its shape, is a strong one, we have reversed the usual conditions of

FIG. 5.—Ayrton and Perry's Electro-motor.—Commutator.

things, and made the armature large and the field magnet small, and from this we have been led to make the armature stationary and surrounding the field magnet, instead of, as usual, the field magnet surrounding the armature. This little thing, then (A, Fig. 4), which I hold in my hand, and which you might at first sight mistake for a Siemens armature without the commutator, is in reality not an armature at all. In our motors the current always flows in the same direction through any portion of the wire coiled on this interior bobbin, A, which is, of course, the condition of a field magnet; while in any part of the wire coiled on E E, the stationary portion of the motor, the current is reversed in every revolution, and this is the condition of an armature. Our small field magnet, then, carries the brushes and revolves inside the stationary armature, the coils of which are joined to the stationary commutator, which, unlike ordinary commutators, we make flat (Fig. 5), to save both space and expense; and in this way we have, we believe, obtained, *weight for weight*, a much more powerful motor than can be obtained by using a dynamo, as well as a more efficient motor *for its size*—that is, the ratio of electric power put into mechanical power given out is greater than in the case of a dynamo of the same size used as a motor.

I say intentionally "for its size," because not only does the horse-power of a motor increase far more rapidly than its weight when the same current is flowing through it, but so also does the efficiency. The increase of power is between the fourth and fifth power of the linear dimensions of the motor, while the weight and cost only increase with the cube. For example, one of our motors, such as there are many examples in this hall driving the various tools, weighing under 40lb., will produce effectively half a horse-power, while one twice as long and of twice the diameter, weighing, therefore, 320lb., or eight times as much, will produce from eight to 10 horse-power, that is from 16 to 20 times as much. Very small motors, producing,

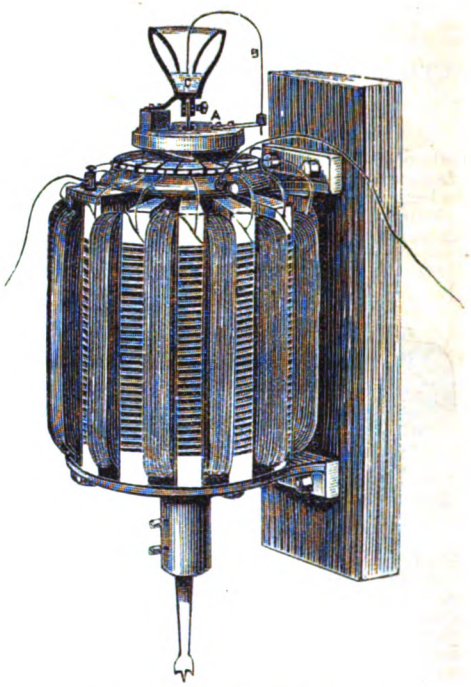

FIG. 6.—Motor, with Drill attached.

say, one-twentieth of a horse-power, can have only quite a small efficiency, are, in fact, not economic converters of power, while motors producing several horse-power, experiment shows, may, when properly constructed, have an efficiency of from 70 to 80 per cent. Why, then, ever use small motors at all if larger ones are so much more efficient? Because the total waste of power when any motor is used to drive machinery does not only occur in the motor itself, but also in the shafting employed to transmit the power to the machine, and in the belting, toothed wheels, or other gearing employed at the machine itself to produce a high speed if it be a fast-speed machine. Consequently, for quick moving, small tools like drills, emery wheels, small circular saws, small electro-motors are of great value, since

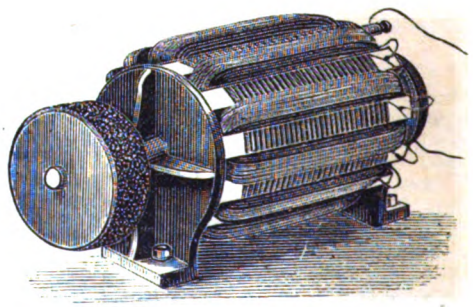

FIG. 7.—Motor, with Emery Wheel attached.

not only does the entire absence of all intermediate gearing, but the enormous convenience of being able to bring machine-driven tools to any part of the work instead of having to bring the work to the tool far more than compensates for the efficiency of small electro-motors being less than that of larger ones. And for large quick-moving machines like fans, centrifugal pumps, screws of small launches, &c., large electro-motors will be invaluable, since they will combine high efficiency with absence of all shafting and the power of shifting the position of the motor and machine at will in the workshops. Hence I believe that for all quick-moving machines, small or large, electro-motors will play an important part in the fitting up of our workshops.

[Portable drills, emery wheels, small circular saws, as well as a fan and a centrifugal pump, were then shown, driven with Ayrton and Perry's electro-motor, sketches of which are given in Figs. 6 to 9.]

But you may have observed in these rough experiments that the motor increased in speed when the work was taken off. If this were unavoidable

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it would be a serious hindrance to the general adoption of electro-motors for commercial purposes. It would never do for a piece of wood or iron in a lathe to rush round when the chisel was taken off, since not only would there be a great waste of power, but on next applying the chisel it would be probably broken by the wood or iron when rotating with such an excessive velocity. It would never do for the screw of an electric launch to race when the boat pitched; this difficulty is bad enough in the present steamers, where a certain amount of racing has to be tolerated because the steam engine cannot be perfectly governed, but with a simple electric motor it would be much worse.

Not only, then, must we arrange, in the way I have described, that the supply of electric energy is proportioned to the demand, but also that the motors consume this energy in proportion to the work they have to do, in other words, the electro-motor must be governed so as always to run at the same speed whatever work it may be doing. The oldest form of governor for motors is what I have called the "spasmodic governor." I will show you it in action, and then you will see the reason for the name

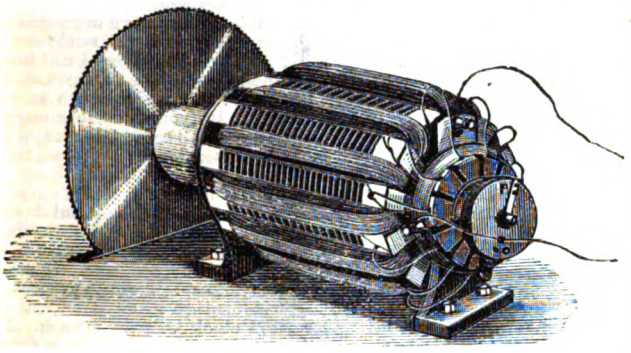

Fig. 8.—Motor, with Circular Saw attached.

(see Fig. 6). The form I am using here is simply a mercury cup revolving with the motor driving this drill. When the mercury revolves, the surface, as you all know, assumes a cup-shaped form, the centre being much lower than the edges. A wire, dipping into the mercury at its centre, carries the electric current into the mercury, whence it passes through the motor; but when the mercury revolves faster than at a certain definite speed, the centre of the mercury becomes so low that the wire ceases to touch it. The current is then temporarily stopped, and the motor slows again until the mercury again rises to the end of the wire.

The objection to this motor is exactly the same as the objection to the ordinary governor supplied with gas-engines—either full power is supplied or no power at all. The result is that the motor slows until a certain moment, when it suddenly receives full power. It then goes off with a rush, continuing to receive full power until it goes so fast that all power is cut off; the speed then rapidly falls, and the same spasmodic action is repeated. Now what we want is, not this alternation of no power and full power, but a supply of power proportionate to the work the motor is doing at any particular moment. To attain this object Professor Perry and I have designed our "periodic governor" for electro-motors, a rough model of which you see in operation here.

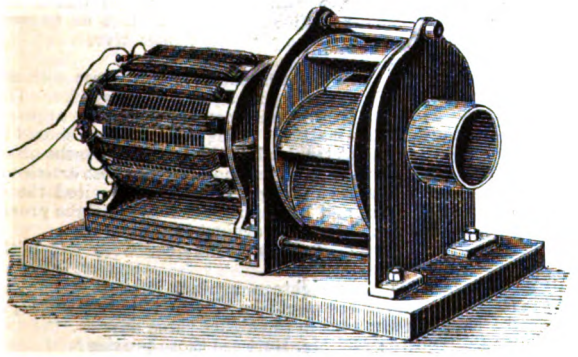

Fig. 9.—Motor, with Fan attached.

If the motors are in series, we arrange that the periodic governor shunts the current periodically instead of introducing resistance.

In some of our motors with flat commutators the periodic governor is constructed as part of the commutator itself, to avoid the necessity of employing any separate apparatus.

With our periodic governor the power is never cut off entirely for any length of time; nor, on the other hand, is full power ever put on for any length of time; but in every revolution power is supplied during a portion of the revolution, the proportion of time in every revolution during which much power is supplied to the time during which less is supplied depending on the amount of work the motor is doing. Our periodic governor, then, differs from the spasmodic governor in the same way that a good loaded governor differs from the governor of a gas-engine.

Having perfected this governor, we then proceeded to abandon it for something better. Why does an ungoverned electro-motor run away when the load is taken off? Because it is using up more of the electric energy than it ought to. Both the spasmodic and our periodic governor operate by diminishing the supply; but there is another way of preventing its running away, and that is by using a brake of some kind to keep the load constant. When the useful work being done is small the brake-power would be large, and when the useful work is large the brake-power would be small, the sum of the two being kept constant. Such a system would obviously be practicable, but not economical, if the brake attached to the motor were to use up the surplus power in producing heat; but supposing the brake stored up the power in some form that could be easily utilised in driving the motor afterwards, then the system of braking would be necessarily be uneconomical, and if the brake was of such a kind that it acted very powerfully when the speed of the motor increased even a little above the normal speed it would be very effective.

Now, such an arrangement we have effected by combining a dynamo with the motor in a variety of different ways. The motor, as is usual, converts electric energy into mechanical energy, while the dynamo reconverts some of this mechanical energy into electric energy, which is added to that supplied by the mains; and by arranging the resistance in the dynamo circuit so that the desired speed of the motor corresponds with the critical speed of the dynamo, the brake power exerted by the dynamo becomes extremely large if the speed of the motor even slightly exceeds the prearranged speed. Here I have an experiment which illustrates our principle in its simplest form. One of our motors is geared with a dynamo, so that both run together, at a speed which is the critical speed for the resistance in the dynamo circuit. You see, on putting a load on the motor, I scarcely at all diminish its speed, and on withdrawing the load the speed of the motor hardly increases. But we can go further than this, for we can combine the motor and the dynamo in one machine. Consider an ordinary series dynamo—if you turn it with the brushes it produces a current, if you supply it with electricity it will run backwards against the brushes. Suppose, now, we wound it with two distinct circuits in *opposite* directions. On sending a current through the core it would turn as a motor one way, on sending it through the other it would turn as a motor the other way. What would happen if you sent a current through both at the same time, and if one of the circuits were less powerful than the other? Why, the current passing through one would make the machine turn as a motor, producing a back electromotive force, so that the current, as is usual in motors, would be checked, while the current flowing through the other circuit would be helped on, since for that circuit the machine is acting as a dynamo. Well, that is the principle of our machine. We wind it with two circuits in *opposite* directions, such that the main current passing through one of them magnetises the armature and field magnets, and so produces the motion, while the main current passing through the other demagnetises the armature and field magnets, tends, therefore, to stop the motion, and is in consequence helped on itself.

I will conclude this lecture by showing you one of the motors thus governed in action, and will reserve until my next lecture, on March 15th, the consideration of the peculiar effect of the lead of the brushes in such motors, and when I shall also consider in detail the construction of the permanent way for electric railways, and of the mains where enormous potentials are employed. I shall also say something about the use of stored electricity for tramcars and tricycles, and when, if the room allows, I will show you our electrically-driven and lighted tricycle running.

THE MEDITERRANEAN EXTENSION TELEGRAPH COMPANY (LIMITED).

The fifty-first ordinary general meeting of the shareholders of this Company was held at the City Terminus Hotel on the 2nd inst., under the presidency of Sir James Carmichael.

After the adoption of the report and the declaration of the dividends on the ordinary and preference stocks,

Mr. Burt said I desire to say a word with respect to what took place at the last meeting. Unfortunately I was ill, and not able to be present, but I observed from a report of what took place at the meeting that there was some misunderstanding with regard to a letter I had written to the secretary respecting the purchase of the Company's undertaking. I am here as an ordinary shareholder of some years' standing—a very small shareholder, I admit—but it appears to me that the position is such that the ordinary shareholders ought to carefully consider the matter. On the last occasion some exception was taken to a paragraph in my letter with respect to the reserve fund, and it was remarked (and I think perhaps truly) that it was no business of the Eastern Telegraph Company what the shareholders should do with their reserve fund. I desire to discharge myself of any impertinence as to that suggestion in this way. I was asked to divide the purchase-money of £40,000 which was offered between the preferred and the deferred shareholders. I said in my letter that I thought it was not my business to do that at all—that it was more for the shareholders to do it, but I was told by an authority almost that I must do so, and I accordingly did it, and it appeared to me, although it was only a suggestion, that something should be said to call the attention of the shareholders to the fact that there was a reserve fund to be divided among them in addition to the purchase money. I see by the report of the meeting that, although the directors had solicited proxies from the shareholders, asking their opinion as to whether the offer should be accepted or not—although there were eighty-three proxies in favour of the purchase and eighteen against, nevertheless the directors did not act on them, but I suppose voted against the proposal, and, consequently, it was rejected. That, however, is an affair of the directors and the shareholders who were then present. Still, I think the shareholders should understand their position. Now, the position is this: The Government guarantee has now ceased; the shareholders can now only look to the revenue of the Company for a dividend in future. For several years past—I have not the accounts by me—but I think I am right in saying that never has there been a net revenue from the earnings of the Company exceeding £1,500. That, sir, is not nearly enough to pay a dividend on the preference shares. Consequently, unless some extraordinary event arises by which the profits of the Company are to be doubled beyond what they

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have been for many years past, it is perfectly clear that the ordinary shareholders can never see a dividend again; and it appears to me that that point was hardly brought out for the consideration of the last meeting. I venture to call attention to it now in order that the matter should be considered. I have no desire to press a sale in any particular way, but I wish to call the attention of the shareholders, and particularly of the ordinary shareholders, to the point that, as far as I can judge, they will never receive a dividend. It appears that the present payment of 1½ per cent., which is only half the amount hitherto paid, is paid out of the Government guarantee of £3,000. The report says: "The claim due from the Treasury for the five months ended the 2nd December, when the Government guarantee expired, is £3,000. This sum will suffice to pay the usual dividend on the preference stock, and also a dividend of 1½ per cent. on the ordinary stock." Now, sir, I invite the attention of the preference shareholders also to their position, because my impression is that they are under a misapprehension as to what their rights are. It is scarcely to be expected that with our large amount of ordinary capital, which I think is £120,000, the shareholders will permit all the profits of the company, being the miserable sum of £1,500 a-year at the outside, to be absorbed by the preference shareholders in future. I should think not. I, for one, should object to it. But if some arrangement were made for the sale of the undertaking, either to the Eastern or to some other company, or in some way to put the affairs of the Company on a reasonable basis, by which there would be something given to the ordinary shareholders and a fair proportion to the preferred, I think then that we might consider that the business of the Company might be carried on as hitherto. But if you look at the detailed statement on the last page you will see how the expenses stand. You see directors' fees and officers' salaries are £441, rent of offices, &c., £57. I do not complain of that being excessive for the Company at all. Then, at Malta, the salary of the superintendent, wages, &c., come to £496. At Corfu the salary of the manager and wages are £222, and the total amount altogether for expenses is £1,663 for the half year. And on the other side you see that the total receipts for messages were £2,307. The report says that the receipts for the last half year were rather less than for the corresponding half year of 1881. But, sir, I cannot find that there ever has been any considerable increase over £2,300 for a half year. If you can tell the shareholders that there is a probability of a large increase, then there is something to wait for, perhaps. But, in the meantime, the £120,000 of ordinary capital which has been spent on the cables is to produce nothing, and we are to go on year after year—I do not know what waiting for—till all the cables are dead, because they are twenty years old, I believe. Mr. Campbell was good enough on a former occasion to give me the dates of the cables when laid, and my impression is that one of them is twenty years old. We can hardly expect that there will be no further repairs to those lines. During the last two years there has been £2,000 spent on the repairs of the Corfu cable, and we know by other companies that repairs are very frequently required, and I suppose that in our case the expense will have to come out of revenue, or, at all events, out of the reserve fund. It seems to me that we are wasting away, and that, unless something is done to realise very promptly, there will be nothing in three or four years left for the preferred or the ordinary shareholders. I think, therefore, that these matters should be taken into very serious consideration.

Mr. HURST: As an ordinary shareholder of the Company I should like to propose a resolution that will have the effect of re-opening negotiations with the Eastern Telegraph Company. The resolution I would propose is—"That a committee of shareholders (say five) be appointed to consider with the directors the expediency of negotiating for the sale of the Company's property, and report to a special meeting on the subject as early as practicable." I do not see that we can possibly gain anything by going on. I do not hold preference shares but I do the ordinary shares, and I do not see any chance of getting a dividend. If we divided our reserve fund it would give us something like 50s. a share, which is better than nothing.

Mr. HERBERT: I second the proposition.

The CHAIRMAN: I would just answer Mr. Burt. There is only one allusion in his remarks that I need answer, because, as far as the negotiations with the Eastern Telegraph Company are concerned, they were fully discussed at the last meeting. The whole subject was then placed before the shareholders in the most open form possible. Your letter was sent to them *in extenso*, without a word altered, and their opinion could be formed of it, and the directors most carefully abstained from influencing the shareholders in any way whatever. I and all my colleagues stated one after the other that we did not wish to affect their views, till we were pressed as to what way we should vote, and then I stated that as a shareholder I would sooner take my chance of holding the property instead of selling it at that price. That I said as a shareholder. The whole thing was discussed fully, but we can go over it again. It was very fully discussed, and the offer was rejected unanimously. I did not think we were called on to use proxies when that meeting was so decidedly against the adoption of the proposal But out of those proxies we had a great many sent to use as we thought best, which we declined to do. A great many were also in favour of the purchase, I am bound to say. Another reason why the Board was very anxious not to use the proxies was that a great number of them (the bulk of them in favour of the purchase) had not been signed properly.

The SOLICITOR (Mr. Campbell): The articles require a witness in this case.

Mr. BURT: The proxies were sent out by the Board in proper form?

The CHAIRMAN: The form was perfectly correct, but many of them were sent back irregularly signed. I merely mention that, because we were glad not to use them.

Mr. BECK: Had the offer been made in money, it would have been very wise to accept it, but when such a small amount had to be paid to the ordinary shareholders it seemed absurd to accept it. If money had been offered as the price it would have been different.

The CHAIRMAN: It was the unanimous decision of the meeting, and the directors did not influence it in any way. If the present meeting wish another offer to be made to the Eastern Company we shall be glad to do so.

A SHAREHOLDER: I beg to move that if it be offered in cash it be accepted.

Mr. FORD: A proposition is before the meeting.

Mr. HURST: My proposal would not bind the meeting, but it opens the question with the Eastern Company, and they might propose something more.

The CHAIRMAN: I think Mr. Burt is the person who had charge of the negotiations, and he will give you his opinion whether they will give you any more. Mr. Burt distinctly told me that they would give no more—in fact, that it was above the value.

Mr. FORD: I should like to know whether the chairman can controvert or explain away the financial position of the company in the future, as prognosticated by Mr. Burt. Is there any prospect whatever of this company's operations realising a dividend for the ordinary shareholders, or indeed of paying the dividend upon the preference shares? I venture to say not. Any man who understands the working of a telegraph property will understand that, and something must be done.

The CHAIRMAN: I quite admit that something must be done.

Mr. FORD: If not the reserve fund will be wasted away. This proposal should be put to the shareholders.

Mr. ATTRELL: I have been connected with companies in the City of London all my life time. I have seen a good deal of committees, and in nine cases out of ten it has been a failure where committees have been appointed. I do hope that we shall have no committee appointed here to assist the directors in a little affair like this. If we have not confidence in those gentlemen to look after our affairs the sooner you send them about their business the better. I say a little concern like this—I call it a little concern—to ask for a committee to go and assist them in negotiating with a large concern like the Eastern Company, they would laugh at you. I say that, if you wish negotiations to go on, let your directors carry them on, but do not let the Eastern Company see that there is dissension among yourselves. Directly they see there is dissension among you, they will say, "Now is our time."

Mr. FORD: Do you suppose they do not read the reports?

Mr. ATTRELL: Perhaps they do; but it is not always put down, and therefore, if an amendment is necessary—however, I shall vote against the resolution. But there will be no committee, I hope, and I trust that you will see with me that it would be impolitic to appoint one. If you have anything to offer to the Eastern Company, do so. I would propose this—that if they will give us a five per cent. debenture we shall accept it, and not 4 per cent., and that all under £100 stock be paid in cash. I think that would meet the little shareholders, and would save them a good deal of bookkeeping and a great deal of trouble, and they can carry on the business of this little affair without much trouble. I would propose that we accept 5 per cent debentures—£50,000, if you like to name a sum total, in 5 per cent. debentures—and that all sums under £100 be paid in cash. I do not know if that suggestion will meet your wishes, Mr. Chairman.

Mr. HURST: I do not wish it inferred that there is any dissension, but the directors have said that they do not wish to take the responsibility, and they did not like to give their advice. At the last meeting we had to press them for their opinion. That being so, it is no dissension to say that we should like to sell our property, with your concurrence, and we should like to negotiate with you to see what terms the Eastern Company would give us. As to what the last speaker said about the terms we shall find that out in the negotiations. But surely as men of business it must be advisable to move now. If a cable break we should have so much less reserve fund to divide. I would ask you to put the resolution Mr. Chairman.

The SOLICITOR: I would say to Mr. Burt, is there not a little inconvenience in passing a motion like this? A larger number of shareholders were at the last meeting who were of opinion that the negotiations should end. If there is to be any renewal should they not be present to say whether they should be renewed?

Mr. FORD: They have been summoned to this meeting. This is a matter I should say for the decision of the meeting.

The SOLICITOR: Let me finish what I was saying. Mr. Burt well knows that a resolution like that is perfectly inoperative as a legal resolution, but if a majority of the shareholders present were of opinion that the negotiations should be begun again by the directors, I have no doubt that the directors would follow the wish of the shareholders. But as to passing a cut-and-dried resolution like this, it is perfectly inoperative.

Mr. FORD: It is perfectly legal.

Mr. BURT: I venture to think the shareholders will agree with me that it is a matter completely for the meeting to agree on if they like. There is nothing binding the Company to a specific course, except the appointment of a committee to consider the matter. Being on my legs I should like to say this: I have been somewhat troubled in the last few months about the question of witnesses to proxies, but I find nothing in these articles about witnesses to proxies. I confess I thought that having invited the shareholders to do what they liked, and having received eighty-three proxies for the acceptance of the offer, and eighteen against it ——

The CHAIRMAN (interposing): A large number were left with the directors to use as they pleased.

Mr. BURT: There were only eighteen against it, and I should have thought the duty of the directors would have been to act on the expressed wish of the shareholders who sent in the eighty-three proxies.

The Hon. A. PONSONBY: Did Mr. Burt see those proxies?

Mr. BURT: No, I did not.

The Hon. A. PONSONBY: I should have liked you to see them.

The SOLICITOR: There were several proxies (I do not quite remember what the point was) that appeared on the face of them to be quite illegal.

Mr. BURT: I dare say that applied to the eighteen as well as to the eighty-three.

The SOLICITOR: I do not know. We will have the proxies looked at and tell you the point, but a great many were not signed at all.

Mr. BURT: How can you call that a proxy? I am not, however, in controversy with Mr. Campbell. I take the report of the meeting at which the chairman said that eighty-three shareholders sent in proxies in favour of the offer. It is also said that there were eighteen against it, and my complaint is that the eighty-three shareholders' views were not attended to at all, and that the eighteen shareholders' were. I desire to point this out to the shareholders also, and to the directors of the Company also.

Mr. ATTRELL: What is the amount of capital the two sections represent?

Mr. BURT: I will say no more. I leave it to the meeting. I think on the last occasion the directors refused to express any opinion as to the proposition, but I am surprised that the directors did not give any advice.

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As they did not, it must be a question for the shareholders to settle outside. The directors are a small body, holding 270 shares. Two are directors of a company competing with the Eastern Company. That may be a good reason why they should not have voted against the offer or for it.

Mr. C. H. ROBINSON: You are wrong.

Mr. BURT: I understood that the chairman and Mr. Ponsonby were directors of the Submarine Company.

The CHAIRMAN: So we are.

Mr. BURT: That company is in competition for a large amount of business with the Eastern Company, and that is a reason why the directors should have hesitated.

The Hon. A. PONSONBY: I hold a largish number of shares in the Company—170; and I do think your offer a good one. I think, Mr. Ford, you are a director of the Eastern Company.

Mr. FORD: No.

The Hon. A. PONSONBY: No? Of the Globe? Well, it is the same thing.

Mr. BURT dissented.

The Hon. A. PONSONBY: I do not think the offer was good enough. I think we may have the negotiations again, and I should like to get a better offer.

A SHAREHOLDER: Can you do so?

The Hon. A. PONSONBY: Ah!

Mr. ROBINSON: This meeting, it appears, has taken a very wrong view of the positon of the Company. The great difficulty the Board have had has been in ascertaining what the shareholders would like to accept. It was no use asking for £3 a share when the market value was only £2. Therefore, as long as you entertain views of that kind, it is useless trying to approach the Eastern Company. A year and a half ago you were offered, I may almost say, £2 10s. per share. Then you repudiated the offer with contempt. You said: "No, unless we get £3 we will not take it." What were the directors to do? The Eastern Company said: "We will not give you £3." It is for you to say or express an opinion what you think your property is worth, because without that the Board have no power. They may say to the Eastern Company, "What will you give?" and the Eastern Company, "What will your shareholders take, and what do you recommend?" You say £2 10s., and they say £3. Another time they say they will give you £1 10s., and you say it was absurd. So it was. Your property is worth more; and there is no doubt, if you keep it long enough, you will realise more. At the same time, you must express some opinion to the Board as to what you think the property is worth. Mr Ford is very well versed in telegraph property. He is a shareholder and, I believe, a director of the West India and Panama Company, which, with all its advantages, is worse off than the Mediterranean Extension, for they pay no dividend at all. They have an immense capital, and pay nothing. Mr. Ford represents the whole of the Board because he was always there, and did everything. If he is so powerful as he expresses himself to be at general meetings——

Mr. FORD (interposing): This is most irregular.

Mr. ROBINSON: I am sure you have only to chalk up to yourselves something that you think the value of your property, and then you will give us some data to go upon, and we will try and carry out your wishes. If we cannot get what you wish, we will see what we can get.

Mr. HURST: I should have been prepared to take £3. I should be very pleased if any one would offer me £2 10s. now. I should be very glad to enter into some negotiations.

Mr. BURT: What is the price in the market?

Mr. HURST: 1½ to 2. I should be very pleased to take £2 10s. I hold 450 shares, and I should be very pleased to sell them. We know in buying and selling we are always willing to take less after a time, and I think this is an occasion for doing so.

Mr. FORD: Mr. Robinson has addressed me personally, and has asked me why I did not get them an offer. If the shareholders place me in a position to endeavour to do something to open negotiations with the Eastern Company, I have not the slightest hesitation in accepting the responsibility; but until I am invited by my fellow shareholders to take that step, I shall not take on myself the invidious position of negotiating on their behalf. That is the only answer I can make to what I consider a very unnecessary and personal reference to myself.

Mr. HURST: Will the chairman put the resolution to the meeting?

A SHAREHOLDER: Is Mr. Ford's resolution an amendment to this?

Mr. FORD: I proposed nothing.

The SOLICITOR: An amendment can be moved if it is wished.

Mr. FORD: The resolution can be negatived; it is a distinct proposition before us.

Mr. ADAMS (to Mr. Ford): Would it not be well for you as you are so anxious in the matter ——

Mr. FORD: I have no anxiety on the subject.

Mr. BECK: The same idea struck me. There is a great anxiety in this room on the part of some one representing the Eastern Company—not this Company—and you had better be careful what you are doing.

Mr. HURST: I have no interest in the Eastern Company. I am a shareholder, but to a less extent than in this Company, and a very valuable property I have there.

The CHAIRMAN: I think you will have placed the Board in rather a false position if this is carried, because at the last meeting you decided something totally different, and I do not know anything to-day that has altered the position.

Mr. BURT: Will you read the proposition?

The CHAIRMAN: "That a committee of five shareholders be appointed to consider with the Directors the expediency of negotiating for the sale of the Company's property, and to report to a special meeeting on the subject as early as possible."

Mr. BURT: It says nothing about the Eastern Company?

The CHAIRMAN: It alludes to the Eastern Company, as no one can negotiate but them.

Mr. FORD: That answers Mr. Adams, who suggested that you should negotiate with some other company.

The CHAIRMAN: There is no other company in the Mediterranean.

Mr. ADAMS: I was stopped when I was going to say a word. By going to the Eastern Company, and continuing begging, you will be doing mischief. I merely want to put it to the shareholders whether, if they were going to sell a horse or any other animal—an ass, say—whether they would go to the buyer on their knees and ask more for it than he had offered already. The property must be sold, or not sold. It is a bad concern, but it is very often that you can get a good price for a bad concern, if you do not keep pressing the matter on the buying company. You had an offer by the Eastern Company, and the shareholders refused to take it. If the Eastern Company are willing to give that now, the directors cannot prevent the shareholders from accepting it if they pleased. But I would not have a committee going on their knees, asking the Eastern Company what they are going to give. Let the matter be placed in the hands of the directors of the Company who wish to go to them again. I would keep out, and try some one else.

Mr. FORD: If you can find them.

Mr. ADAMS: It must be left to the shareholders to decide what they wish. If they wish a committee let them have it. If they go to the Eastern Company again, asking for more, they will probably get less. That is my experience of business. I think there are many other companies in the market that might like to take up your cable as a nucleus.

Mr. FORD: Will you mention a company?

Mr. ADAMS: Let me finish, and then I shall be glad to hear your ideas. I will not weary you much longer. If the directors cannot get a better price for it, or if they cannot get a better offer for it, as one of the directors—Mr. Robinson—has said, let the shareholders say what price they will take, and then let us try and see if we can get it.

A SHAREHOLDER: May I ask if Mr. Ponsonby's mind has changed since the last meeting?

The Hon. A. PONSONBY: The offer was one which, as a shareholder, I should not have liked to accept. I would not give my opinion as a director as I said at the time, because I ought not to bias any one's mind. I am not a preference shareholder but an open holder, and I said I did not think the offer was one that I should like to take, and that I would prefer taking my chance, and trust to the chapter of accidents. My views are the same now. I daresay the Eastern Company felt they could not give more, but I did not think it sufficient, and, therefore, as I told you, speaking as a shareholder, I should vote against anything in the shape of accepting the offer that was then made. As a director, I gave no opinion about it.

The CHAIRMAN: I think it is only fair to tell you that we do not agree to this proposition. As chairman of this Company, and as a member of your Board, I shall be most happy to carry out any instructions, but I could not put myself in a false position, and go and ask the Eastern Company, backed up by several shareholders, to buy us up.

Mr. FORD: That is not the proposition. It is not proposed that you should go to them. There is no proposition of the kind.

The CHAIRMAN: It is a proposition to go to someone, "That a committee of five shareholders be appointed to consider with the directors the expediency of negotiating for the sale of the Company's property, and to report to a special meeting on the subject as early as possible."

Mr. FORD: That meets the views of Mr. Adams, but does not bind you in the least. We wish you to go to the best buyer.

The CHAIRMAN: That is moved and seconded. Will the shareholders signify their approval of it in the usual manner? To the contrary. Then it is rejected. That concludes the business of the day.

Mr. FORD: I have a poll to ask for. Will you let me see a copy of the Articles of Association, to see in what form I can put it?

The SOLICITOR: Any five shareholders present at any meeting may demand a poll. [Read clause in Articles of Association on the subject.]

Mr. FORD: Then I hope we shall have a poll at once.

A SHAREHOLDER: I think a poll is entirely unnecessary.

Mr. FORD: I will sign the demand if you give me a piece of paper.

A SHAREHOLDER: Are there five to demand a poll?

Mr. FORD: If four other shareholders besides myself will sign the demand I will write out the request for a poll.

Mr. BURT: Might not this be avoided if you have this matter brought before another meeting specially called for the purpose? I feel that you are in a most awkward position, and so am I. My belief is that the shareholders do not and did not understand their position. If you will have a meeting convened specially for the purpose, you might have a definite resolution on the matter.

The CHAIRMAN: We have done that.

Mr. BURT: No; you had eighty-three shareholders for it and eighteen against it, and then you accepted the eighteen, and refused the eighty-three.

The CHAIRMAN: You leave out those proxies which were illegal. The bulk of the shareholders did not sign.

Mr. FORD: I saw by the report of the last meeting that eighty-three shareholders sent in proxies in favour of the offer of the Eastern Company. There were eighteen against it, and twenty-one sent in proxies requesting the directors to vote as they thought best; so you see eighteen and twenty-one make thirty-nine against eighty-three for the offer. When will the poll close?

The SOLICITOR: It cannot be closed in less than four hours from now. That will be six o'clock.

Mr. ADAMS: I do not think it is a legal way of doing it without notice.

Mr. FORD: Your objection comes too late, Mr. Adams.

The SOLICITOR: The poll is now open, and it will close at six.

Mr. BURT: When will the result of the poll be declared? I suppose you will adjourn the meeting until Monday or Tuesday?

The SOLICITOR: I do not know whether the directors will be here at the close of the poll.

Mr. BURT: I suggest that you adjourn the meeting until Monday at twelve o'clock.

The CHAIRMAN: I think we had better take the poll now, or you will not get people back.

The SOLICITOR: The poll is open now, and it will close at six o'clock.

Mr. BURT: Supposing the resolution is carried, you must carry it out by appointing a committee.

Mr. FORD: A suggestion might be made, which might possibly meet the views of the Board and the shareholders who are of opinion with you that it is inexpedient to appoint a committee. What I suggest is that some expression of opinion should be given on the part of the Board—that if any gentlemen here present as shareholders think proper to bring any proposition to the consideration of the Board, either from the Eastern Company or some other company, that the Board will submit it to the shareholders at a special meeting to be called for that purpose. There

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you have the question raised independently, and then probably the challenge which has been given to me by Mr. Robinson will be taken up.

Mr. ADAMS: That is a perfectly fair proposition.

The Hon. A. PONSONBY: You get a larger offer.

Mr. FORD: Then I think we may save the shareholders further trouble if the directors, through the chairman, say they agree to this suggestion.

The CHAIRMAN: I have never kept back any offer, and I never would.

Mr. FORD: Do I thoroughly understand you that if any number of shareholders here present think proper to approach the Eastern Company, or any other company, and obtain an offer from the Eastern Company, or any other company, that you will call a special meeting to consider that proposal?

The CHAIRMAN: Certainly.

Mr. ROBINSON: Of course.

Mr. FORD: Then I do not think it is worth while now proceeding with the poll.

Mr. BURT: But if a meeting is called, and the directors will not give any advice about it ——

Mr. FORD: Well, after what has taken place the Board must do something.

Mr. BURT: I think that Mr. Adams has some one in his mind.

Mr. ADAMS: I have.

The Hon. A. PONSONBY: We only want the best offer we can get for our shareholders.

Mr. ROBINSON: Mr. Ford seems to entertain a wrong opinion—that the directors on this Board are adverse to any meeting.

Mr. FORD: I have not expressed any opinion on the subject.

Mr. ROBINSON: The Board have always been desirous of an amalgamation, and no doubt if Mr. Ford, if the Eastern Company, with which I believe he is connected, will bring forward some offer that is tangible, the Board will only be too happy to entertain it, and therefore, with such a view, I think, having a committee would be really frustrating the object Mr. Ford has in view.

Mr. FORD: Are you not mistaken in what you say?

Mr. BURT: It took me more than three months to get the last offer put before the shareholders.

Mr. FORD: I am entirely in the hands of the meeting. A poll has been demanded, and cannot be withdrawn, if Mr. Burt objects.

Mr. BURT: I do not want the affair to sleep and die, as it will if we go on as now.

The CHAIRMAN: Are we to go to a poll or not?

Mr. FORD: Very well, then; let it continue.

Mr. ADAMS: Have you not settled, Mr. Ford?

Mr. FORD: I cannot. Will the gentlemen now, who are favourable to the resolution, sign the demand for a poll?

The SOLICITOR: Two o'clock on Monday is the time appointed to declare the result of the poll.

Mr. FORD: It closes at six to-day.

The proceedings then terminated.

The adjourned meeting was accordingly held last Monday at the City Terminus Hotel, under the presidency of Sir James Carmichael.

The SOLICITOR read the result of the polling as follows:—For the resolution seven shareholders, in person, representing 708 shares and 105 votes; against the resolution thirteen shareholders, in person, representing 534 shares and 77 votes. The proxies in the hands of the directors were nine, representing 1,160 shares and 190 votes. This made 267 votes against the resolution, and 105 votes for it.

The CHAIRMAN having formally declared the resolution lost,

Mr. BURT inquired if the directors claimed to act on the votes given them by proxy?

The CHAIRMAN: Certainly.

Mr. BURT stated that they were not referred to at the last meeting. Had it been intimated that the directors held proxies, he did not think that the demand for a poll would have been pressed. He was sorry that the shareholders were not given this information, as he believed it would have saved trouble and some expense. It appeared, however, from the figures read by Mr. Campbell that the votes in favour of the resolution given in person—that was, by those who had a knowledge of the facts—considerably exceeded those of the shareholders who voted against it, who did not possess a knowledge of the facts.

The SOLICITOR admitted that there was a small excess.

Mr. FORD stated that from what Mr. Burt had said the resolution had practically been carried. It had been carried by the votes of the shareholders present, but it had been defeated by the votes of proxies held by the directors. It had not been stated at the time by the directors that proxies were held by them, or that they were intended to be used by them.

The SOLICITOR: That shows what an irregular proceeding it was to allow the resolution to be put at all, seeing that the majority of the shareholders, being absent, knew nothing about it.

Mr. BURT: That irregularity, of course, must rest on the solicitor of the company.

The SOLICITOR: The solicitor of the company pointed out the irregularity, but deferred to the minority of the shareholders.

The CHAIRMAN stated that he must himself accept the responsibility, for he had overruled Mr. Campbell's advice, wishing to give the shareholders an opportunity of expressing their opinion.

Mr. BURT, after remarking that no harm had been done, moved a vote of thanks to the chairman.

Mr. THOMAS ADAMS seconded the motion, which was carried unanimously.

The CHAIRMAN briefly replied, and the proceedings then terminated.

ELECTRIC LIGHTING IN MELBOURNE. The Melbourne City Council, at a meeting held on January 15, resolved to ask the city members to introduce a Bill for the electric lighting of the city.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES MAR. 3.		BUSINESS DONE WEEK ENDING MAR. 3. Highest.	Lowest.
Anglo-American	51,	52	51¼	51¼
Do. Preferred	82½,	83½	83½	82
Do. Deferred	19½,	20	20	19½
Brazil Submarine	12½,	12¾	12 11-16	12½
Cuba	10,	10½	10½	10
Do. Preference	16½,	17½	17½	17½
Direct Spanish	6½,	6¾	6¾	6½
Do. Preference	16,	17	—	—
Direct United States Cable	12½,	12¾	12¾	12½
Eastern Telegraph	10½,	11½	11	10¾
Do. 6 per Cent. Preference	13,	13½	13¾	13¼
Do. 5 per Cent. Debentures, 1899	103,	106	105½	101½
Eastern Extension	11½,	11¾	11 13-16	11 11-16
German Union	10½,	11½	—	—
Globe Telegraph and Trust Company.	6½,	6¾	6¾	6¾
Do. Preference	12½,	12¾	12¾	12¾
Great Northern	12,	12½	12¾	12½
Indo-European	32½,	33½	32¾	32½
Mediterranean Extension	1½,	2	1 11-16	1 11-16
Do. Preference	7,	8	—	—
Reuter's	10½,	10¾	10½	10½
Submarine	250,	255	252	252
West India and Panama	1½,	1½	17-16	1½
Do. 1st Preference	7½,	7¾	7½	7
Western Brazilian	7½,	8½	8½	7¾
West. Union 7 per Cent. 1st Mortgage	122,	128	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	102½	102¼

TELEPHONES.

Consol. Telephone and Maintenance	¼,	1½	1	13-16
Oriental	¼,	¾	½	11-16
United Telephone	11¼,	12¼	12½	11¼

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	7,	7½	81-16	5½
Do. (fully paid)	9',	10½	10 13-16	8½
Hammond Light	4,	4½	4½	3½
Eastern Electric (fully paid)	1,	1½	—	—
Pilsen, Joel, and General Electric	½,	1	—	—
Swan	1½,	2½	21-16	1½
Maxim-Weston	½,	¾	7-16	

TRAFFIC RECEIPTS FOR FEBRUARY, 1883.

COMPANIES.	Feb., 1883	Feb., 1882.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,900	3,271	629	—
Direct Spanish Telegraph Company	1,544	2,109	—	565
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	46,667	44,046	2,621	—
Eastern Extension Telegraph Company	29,391	27,473	1,918	—
Great Northern Telegraph Company	17,800	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during the month of February was 4,400, estimated to produce £3,900, against 3,349 messages, producing £3,271 in the corresponding month of last year. The traffic receipts for the month of November, estimated at £1,800, realised £1,842.

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SLIP

SPAIN.—The cable between Falmouth and Bilbao is interrupted.

WEST INDIES.—Telegraphic communication with all the West India Islands and with British Guiana is now restored.

ELECTRIC LIGHTING FOR THEATRES.—It is stated that the Court Theatre, in Dresden, is to be lighted by the Edison system.

THE EDISON SYSTEM IN BOSTON (AMERICA).—One hundred and fifty Edison lamps are used in the new building of the Boston *Advertiser*.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended the 9th inst. amounded to £4,577.

ELECTRIC LIGHTING IN SOUTH AFRICA.—Recent news from South Africa says that the Town Council of East London has agreed to adopt the electric light.

BATTERIES AT THE POST OFFICE.—There are 87,221 Daniell, 56,420 Leclanché, and 21,846 bichromate cells at present in use in the British Post Office telegraph system.

ELECTRIC LIGHTING FOR OTTAWA (CANADA).—The Corporation of Ottawa is negotiating with a New York company with regard to lighting the city by electricity.—*Colonies and India.*

CIVIL SERVICE ESTIMATES.—According to the estimates for the year ending 31st March, 1884, £1,550,073 will be required for Post Office Telegraphs. This is an increase of £114,157 on last year.

DIVIDEND.—The directors of the Brazilian Submarine Telegraph Company have declared an interim dividend of 3s. per share, or 6 per cent. per annum, free of income-tax, for the quarter ended December 31st last.

ELECTRIC LIGHTING IN SYDNEY.—It is stated that the General Post Office, Sydney, is to be lighted by electricity. The sorting room of the postal department and the operating room of the telegraphic department are to be lighted on Edison's system.

ELECTRIC LIGHT AT NEWLAND HALL.—Newland Hall, near Normanton, the residence of William Locke, Esq., has been lighted throughout by means of Swan lamps and a Siemens dynamo. Messrs. Tasker, Sons, and Co., of Sheffield, are the engineers.

EDISON SYSTEM IN MELBOURNE.—News from Victoria says that the Chamber of the Legislative Council was illuminated on the evening of January 22 with the Edison electric light, in order that visitors from South Australia and Queensland might be able to compare it with gas.

ELECTRIC LIGHTING ON SHIPS.—The "Doric," a new steamer recently built by Messrs. Harland and Wolff, of Belfast, for the White Star Line of Liverpool, is to be lighted by incandescent lamps. She is 440ft. long, 44ft. broad, 32ft. deep, and has a gross tonnage of 5,000 tons.

THE ELECTRIC CARBON COMPANY.—On the 10th inst. a petition for the compulsory winding up of this company, which was already in voluntary liquidation, was heard before Vice-Chancellor Bacon. The petitioner described himself as a judgment creditor in respect of services rendered by him as solicitor. The petition was dismissed.

THE ROYAL SOCIETY.—On Thursday a paper was to be read before this society by Staff-Commander Creak, having for its title, "On the Changes which take place in the Deviations of the Standard Compass in the Iron Armour-plated, Iron, and Composite-built Ships of the Royal Navy, on a considerable change of Magnetic Latitude."

EDISON'S 100-CANDLE LAMP.—In our Notes last week, describing an exhibition of Edison's 100-candle lamp at Glasgow, its dimensions were accidentally enlarged to mammoth proportions. Those of our readers acquainted with incandescent lamps will readily recognise that the figures given should be reduced to inches instead of feet.

COMMUNICATION WITH THE WEST COAST OF AMERICA.—The West Coast of America Telegraph Company announce that telegraphic communication with Valparaiso, Mollendo, Arica, Iquique, Antofagasta, Santiago de Chili, Buenos Ayres, and all telegraph stations in Peru, Chili, and the Argentine Republic, is now re-established *viâ* Galveston.

ELECTRIC LIGHTING AND THE TRANSMISSION OF POWER.—Mr. A. Reckenzaun, C.E., of the Electrical Power Storage Company, is to lecture on this subject at the Working Men's College, 45, Great Ormond-street, W.C., this evening (Saturday), at 8:30. Sir Daniel Cooper has promised to preside. Admission is free, by means of tickets to be obtained of the secretary.

THE TELEPHONE AT WALSALL.—At a meeting of the Walsall Chamber of Commerce last week it was resolved, on the request of the Telephone Company, to petition the Postmaster-General in favour of making West Bromwich a licensed centre, as communication between Birmingham, Walsall, Wolverhampton, Tipton, Dudley, &c., would thus be made much cheaper.

TELEPHONES AND TELEGRAMS.—Mr. Monk, M.P., as President of the Associated Chambers of Commerce, has forwarded memorials to the Postmaster-General urging a reduction in the charges for the use of telephones. Furthermore, the Government is requested to enter into negotiations with foreign countries for the purpose of cheapening and facilitating telegraphic communication.

THE FISHERIES EXHIBITION.—The Executive Committee of the International Fisheries Exhibition have decided, we hear, to light their galleries by electricity, and they have already made arrangements for the illumination of fully two-thirds of the area. Messrs. Davey Paxman and Co. have undertaken to supply the necessary motive power, which has been estimated at little less than 700 h.-p.

ELECTRIC LIGHTING.—Mr. Andrew Jamieson, Principal of the College of Science, Bath-street, Glasgow, gave a free lecture on this subject under the auspices of the Mining Institute of Scotland, on the 9th inst., at Hamilton. The principles of electric lighting were explained, and a number of lamps and machines shown and described, amongst them being the Brush, Gülcher, Crookes, Edison, &c.

TELEGRAPH BOYS.—On Thursday evening last the annual winter gathering of telegraph boy messengers employed in the East Central District took place at the Lecture Hall of the Weigh House Chapel, Fish-street-hill, E.C. Three hundred boys were supplied with a substantial tea. Later on they were addressed by various gentlemen, and congratulated on the improvement they had made during the past year.

THE ELECTRIC LIGHT IN SWITZERLAND.—A *Daily News* correspondent says that a scheme is proposed for lighting the whole of the Canton of Vaud by electricity. The motive

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force would be derived from turbines of five thousand horse-power at Vallorbes, and, the water supply being constant and abundant, it is believed that gas, which is very costly in Switzerland, may be entirely dispensed with throughout the district.

Electric Lighting in Brighton.—The Hammond Electric Light Company have now something like 10 miles of line in Brighton, supplying between 40 and 50 Brush lamps. The current is supplied by two Brush dynamos, a 16 and 40-lighter. It says something for Messrs. Hammond's workmanship and care that no accident has yet occurred, although the currents are of high tension, and shows that where proper precautions are taken these currents can be used with safety.

The Edison System on Ships.—We understand that the ss. "Clan M'Arthur," launched this week at Greenock, is to be fitted up by the Edison Company with their system of electric light. In addition to the "Clan M'Arthur," the company have on hand contracts to light up the ss. "Apollo," and ss. "Minerva" at Messrs. Wm. Denny Bros., Denny's Yard, at Dumbarton; the ss. "Pateena," at Messrs. J. and A. Inglis, Pointhouse, and the ss. "Rio Pardo" and ss. "Rio Parana" at Messrs. Caird's yard, at Greenock.

Electric Lighting at Norwich.—The Hammond Electric Light Company, of 110, Cannon-street, E.C., have recently installed 200 Swan lamps in Colman's mustard factory at Norwich. It is intended to increase this number considerably in the future. The current is supplied by a Ferranti dynamo. Mr. Colman has also had his library and drawing room lighted by means of twenty Swan lamps, the current for these being supplied by Sellon-Volckmar accumulators, which are charged during the daytime by the above dynamo machine.

Electrical Patents in the United States.—According to a speech recently delivered by Mr. Edward M. Bentley, one of the examiners in the electricity division of the United States Patent Office, about 2,000 applications for patents relating to electricity were filed in 1882, of which about two-thirds were granted. To show how the subject had grown in importance within a very few years, Mr. Bentley said "that in 1877 electricity was a sub-class in a division. Now it was the largest division in the office and regarded as the most important."

Electric Lighting in Nottingham.—The lace factory known as Player's Mill, Nottingham, is being lighted by means of Swan lamps. This factory is let out in floors to lace manufacturers by the owner, who also supplies them with light and power. Hitherto gas has been employed, but it is now being superseded by the incandescent light, and we believe that the change is universally appreciated by the *employés*. The current is supplied by a Ferranti dynamo, which will feed 500 Swan lamps. The work is in the hands of the Hammond Electric Light and Power Company.

The Lighting of Brooklyn Bridge, New York.—The following estimates have been received by the Brooklyn Bridge Trustees for supplying seventy lights, the price to include engines, dynamos, conductors, and everything except steam. The Arnoux-Hochausen Electric Company, 15,750 dols.; United States Illuminating Company, 18,150 dols.; Schuyler Electric Light Company, 20,000 dols.; Edison Electric Light Company, 21,500 dols.; Brush-Swan Electric Light Company, 23,273 dols.; Fuller Electric Company, 25,455 dols. The matter of decision has been referred to a committee, preference being accorded to the estimate of the United States Company.

The Aquarium Exhibition.—On Wednesday evening what may be called the opening of this exhibition took place. Much progress has been made during the last few days in fixing up the lamps and machines, and the exhibition may be said to be fairly complete. In order that there shall be no lack of the sensational element, Messrs. Paterson and Cooper have fitted up a large arc light at one end, close to the roof; this is said to be of 100,000 candle-power. The current is supplied by an Elphinstone-Vincent machine. There are some prettily arranged rooms lighted by Swan and Edison lamps, and an imitation grotto, all of which well demonstrate the suitability of the lamps for indoor lighting purposes.

Renewal of an Electro-plating Patent.—The Plating Company, of 34, Kirby-street, Hatton Garden, E.C., have given notice that they intend to apply for a prolongation of the terms of letters patent granted to William Brookes, of 62, Chancery-lane, civil engineer and patent agent, for the invention of "improvements in the electro deposition of nickel," a communication from abroad by Isaac Adams, jun., of Boston, Massachusetts, in the United States of America, bearing date the 28th October, 1869, and numbered 3,125, and which letters patent were assigned to the said Plating Company. Notice of opposition to this application must be lodged at the Privy Council Office prior to the 25th April next.

Telegraph Expenditure and Revenue.—An account prepared by the Treasury, on an order by the House of Commons, shows that the gross amount received on account of the telegraph service in the year ended 31st March, 1882, was £1,654,390 13s. 6d., and the expenditure £1,440,498 6s. 10¼d., leaving a balance to meet interest on stock created on account of the telegraph service and the redemption of debt of £213,892 6s. 7¾d. The interest on this capital stock, amounting to £10,880,571 5s. 2d., was for the year to 5th January, 1882, £326,417 2s. 9d., so that there was a deficiency in the telegraph revenue for the last financial year of £112,524 16s. 1d. The total amount of deficiency from 1st January, 1872, to the 31st March, 1882, was £1,330,350 8s. 10d.

Electric Lighting for Hastings.—This favourite seaside resort is likely ere long to have a very compact electric lighting station. We understand that the building itself is already erected, and that arrangements are being made for fitting up two 40-light Brush dynamos, which are to supply current for Brush lamps to be erected on the sea front, in shops and streets, &c. It is intended to have engine power up to 250 horses or more, as soon as the necessary arrangements can be completed, and to start supplying electricity for light and power purposes on a practical scale. The station is in the hands of the Hastings Electric Light Company, which some time since purchased a concession for that district from the Hammond Company. When things are in their place we hope to give a more detailed account, with illustrations, of this station.

A Tangent-Galvanometer for Measuring Powerful Currents.—This instrument, designed by the late F. J. Pirani, M.A., is extremely simple in its construction, and, at the same time, portable and accurate. It consists of a band of copper doubled on itself, and then bent so as to form two concentric circles in one plane of slightly different diameters, through which a current will flow in opposite directions. Suspended at their common centre is a magnetic needle, the deflection of which can be read off by an index traversing a divided circle, or by a mirror reflecting a beam of light on to a scale in the ordinary manner. The leading wires are twisted together to eliminate their effect on the needle. The

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paper is illustrated by a diagram of the arrangement.—Abstract from the *Transactions* Roy. Soc. of Victoria, appearing in abstracts from foreign publications, &c., published by the Institution of Civil Engineers.

Hail and Thunderstorms.—A correspondent of the *Scotsman*, writing from Prestonkirk on the 8th inst., says:—"About 7:30 a.m. the sky was quite clear. In less than twenty minutes there was a general darkness, followed by a short but severe thunderstorm, during which the lightning was very vivid and near at hand. The storm coming from the north-east, and accompanied by a more than ordinary high wind, sent the hailstones—every one as large as marbles—with full force against all windows with an eastern exposure. At Seacliff nearly 100 panes of glass were rendered useless, and at Newbyth about 200 more, whilst other places in the line of the storm suffered more or less from its effects. The real force of the storm seems to have been between Tantallon Castle and two miles southwards, losing force as it travelled landwards. Many of the hailstones, after two days' exposure, are still to be seen, almost undiminished in size, showing the hardness of their nature. Many birds were found, after the storm had passed over, not only with broken wings, but without life, evidently struck on some vital part by the hailstones."

The United Telephone Company v. Hebden.—This case was heard before Mr. Justice Fry on the 10th inst. It may be remembered that about a fortnight ago his lordship made an order, committing the defendant to prison for contempt of Court, in not obeying an injunction restraining the infringement of the plaintiffs' patent for Bell's receiver, and for the delivery up of instruments. On that occasion the defendant appeared in person; he has since been lodged in prison.—Mr. Renshaw now moved to obtain his discharge on certain affidavits.—Mr. Moulton, for the company, said they left the matter in his lordship's hands, but thought it desirable to point out discrepancies in the defendant's evidence. —Mr. Justice Fry said if the defendant had come here with a simple apology and expression of regret, he should have had no hesitation in discharging him; but instead he had thought fit to file an affidavit with a view to justify and explain his conduct. In his lordship's view, that affidavit was entirely false, and was a repetition of his previous offence—namely, making a false affidavit to deceive the Court. He thought this a similar attempt, and should make no order on this application, except that the defendant should pay the costs.

Underground Wires.—Mr. Monk, M.P., as President of the Associated Chambers of Commerce of the United Kingdom, has forwarded memorials to the Postmaster-General, urging, amongst other things, that in consequence of the frequent interruption of telegraphic communications by storms the Government should take steps to have the principal lines of wire conveyed underground. It may not be out of place to record here the latest dictum on this subject. Mr. W. H. Preece, F.R.S., in a recent paper says, speaking of the Post Office system:—"Wires are almost invariably carried underground through towns. Copper wire insulated with gutta percha encased in iron pipes is the material used. There are 12,000 miles of underground wire in the United Kingdom. There in a great outcry for more underground work in England, owing to the destruction to open lines by gales and snowstorms; but underground telegraphs, wire for wire, cost at present about four times as much as overground lines, and their capacity for the conveyance of messages is only one fourth; so that overground are, commercially, sixteen times better than underground wires. To lay the whole of the Post Office system underground would mean an expenditure of about £20,000,000. Hence there is no desire to put wires underground except in towns. Besides, snowstorms are few and far between, and their effects are much exaggerated."

Accumulators.—In an interesting article on the progress made in the applications of electricity since the Paris Exhibition in 1881, which appeared in last Wednesday's *Times*, and occupied four columns of that paper, the author, after dealing with lamps, dynamos, power transmission, &c., speaks of accumulators. Having alluded to Planté's, Faure's, and the Faure-Sellon-Volckmar batteries, and the respective advantages offered by each, with the methods adopted by the inventors for the formation of the plates, goes on to say:—"Other inventors have produced the lead in a finely divided powder by deposition from the acetate of lead or other means; and by compressing this powder into a compact mass they have obtained sheets of very porous lead. The rapidity with which accumulators made of this material can be "formed" is remarkable, and those who have made experiments on these plates find them to be superior to any others. It seems, then, that after all the excitement which was raised about the Faure battery, we are likely to return eventually to a form which resembles a Planté secondary battery to a much greater extent. It is satisfactory to know that the chemistry of these secondary batteries continues to be carefully studied by Dr. Gladstone and Mr. Tribe, and also by Professor Lodge. Their chief result is that the action observed in these secondary batteries s largely influenced by the sulphate of lead formed by the presence of sulphuric acid in the cell. These researches promise to help greatly in the future development of the invention."

Electric Lighting at the Law Courts.—Lord Chief Justice Coleridge having made complaints of the failure of the incandescent lights in his court on Thursday week, Messrs. R. E. Crompton and Co., the engineers, wrote explaining that it arose from a mistake made by one of the attendants at the courts, who told their men that all the courts had risen, and consequently the lights were turned down as usual previous to their being extinguished for the night. Messrs. Crompton write further that "Lord Coleridge had himself stated in court that he would not sit after 4:30, whereas the jury had not given their verdict until 7:15. Meanwhile the attendant on going his rounds, and seeing no one in the corridors, made the not unnatural mistake of supposing all the courts had risen, and gave the order to turn down the lights. After the mistake was discovered, it was impossible to turn the lights up to their full brilliancy, as the engine driver had let his steam down. There will be no possibility of such a mistake occurring in future. We take this opportunity of stating that, as far as we are aware, there has not been the least hitch or trouble with the electric light since the courts were opened." We do not think the present mistake would have been so serious in its results had Messrs. Crompton had a few secondary batteries ready charged on which to fall back in cases of emergency. The contractors for the lighting of the New Law Courts must remember that such mistakes greatly injure electric lighting in the public estimation, and if they can be guarded against by a little extra care and precaution, such should not be wanting.

"Electric Light in Our Homes."—On Tuesday night Mr. Robert Hammond, of the Hammond Electric Light and Power Supply Company, delivered before a crowded audience at the Highgate Literary and Scientific Institute a lecture upon "Electric Light in our Homes;" Professor Tomlinson, F.R.S., in the chair. A feature of the entertainment was the

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erection upon the stage of a miniature drawing room, displaying throughout the ordinary surroundings of a home, showing the adaptability of the electric light for home use. The lecturer dwelt at some length upon the fact that all the lighting agents which have been used by man since the very earliest days, from the rough fire of the savage to the gas of the present day, have all had one feature in common, viz., that they have been more or less brilliant, according to the greater or lesser amount of oxygen abstracted from the air, and he stated that if philosophers met together to devise a perfect light, they would consider it essential that the light should be (1) one which should not rob the air of oxygen; (2) nor add noxious fumes; (3) to be capable of sufficient sub-division to avoid affecting the eye unfavourably; (4) and be no element of danger in a house. All these conditions, he stated, were fulfilled by the incandescent lamp. After touching upon the various processes of the manufacture of the lamp, the lecturer dwelt upon the question of conductors, and then detailed the way in which the electric current was produced in the dynamo machine, the way in which this was stored in the accumulators, and the way in which it could be measured in passing into houses from central stations. The "Sellon-Volckmar" accumulators were used for the lighting of the drawing room, and for various experiments during the evening. As hundreds were turned away from the doors, the lecturer promised to deliver the same lecture again at an early date.

Telegraph Instruments.—In a recent lecture, Mr. Preece said, speaking of the telegraph instruments in use at the present time:—"The A B C is the simplest to read, for it indicates the letters of the alphabet by causing a pointer to dwell opposite the desired letter. There are 4,398 in use. Its mechanism is, however, complicated and expensive, and it is being rapidly supplanted by the telephone. The needle instrument is the simplest in construction, but it requires training to work it. There are 3,791 employed by the Post Office, and 15,702 among different railway companies. As a railway instrument it is the simplest, cheapest, and most efficient ever devised. The Morse instrument, of which the Post Office possesses 1,330, records its letters in ink, in dots and dashes on paper tape, and, like the needle and A B C, appeals to the consciousness through the eye. It also indicates the letters of the alphabet by sound, and thus utilises the organ of hearing. Sound-reading is gaining ground in England with great rapidity. There are now 2,000 sounders, while in 1869 there were none. In America scarcely any other instrument is used, but on the Continent of Europe there is scarcely one. Acoustic reading attains great perfection in Bright's bell instrument, where beats of different sound replace the dot and dash of the Morse alphabet. Sound reading is more rapid and more accurate than any system of visual signals or permanent record. The Hughes type instrument, which prints messages in bold Roman characters, is much used on the Continent; it is, in fact, recognised as the international instrument, but it has had to give way in England to a more rapid system of telegraphy. It is, however, solely employed for the Continental circuits by the Submarine Telegraph Company." After describing duplex and quadruplex circuits, Mr. Preece said:—"There are in England 319 duplex and 13 quadruplex circuits at work. The acme of efficiency in telegraphy is attained in the automatic systems, in which manual labour is supplanted by mechanism in transmitting the messages. There are 71 circuits worked by these instruments, and 224 instruments in use, and a speed of working of 200 words per minute is easily maintained upon them. With the hand alone from 30 to 40 words per minute is the maximum rate attained, but by automatic means the limit is scarcely known. Since this system can be duplexed, and in many cases is so, 400 words per minute on one wire are easily sent. By the use of high-speed repeaters the length of circuit for automatic working is scarcely limited; it would be easy to send 100 words per minute to India."

City and Guilds of London Institute.—We have before us the report of the council of this institute, presented to the governors at a meeting held on Wednesday, March 14, 1883. Technical education is a subject of the greatest interest, and one on which there may be various opinions. We have advocated—we shall continue to advocate—the work of the institute, not because we think it is perfect or approaching perfection, but because the work is in the interests of technical education. We shall not this week deal with the report proper, but confine our remarks to the reports of the examiners and the examinations. The examination papers, so far as electrical subjects are concerned, have been given in our columns, and a number of solutions have also been given. Thus, our readers are fairly acquainted with the papers, and, it may be, are in some measure prepared for an adverse report from the examiners. The following are extracts from the reports of the examiners in telegraphy and in electric lighting:—*Telegraphy* (W. H. Preece, Esq., F.R.S., Examiner): "The papers of the competitors in the first class of the Honours examination are of very fair merit. The replies given in the Ordinary, or Pass, examination are not altogether of a satisfactory character, except in one or two cases. The competitors who have taken but a low place in the second class, and those who have not passed, have, in many cases, shown that the knowledge they possess of the subjects they deal with is of a mere mechanical nature, and has simply been attained from constant practice at a particular system with which they have had to deal, and they appear to have but little notion of the broad principles upon which that particular system is founded; thus, for instance, they describe at full length, and quite correctly, the methods of making tests with particular forms of apparatus, but it is quite evident that if these tests had to be made with instruments which were slightly different in character to those described, the experimenter would be unable to carry them out. In one or two instances the answers given have been merely definitions, such as would be found in any technical dictionary. Altogether, I think the character of the papers submitted is superior to those of former years."—*Electric Lighting*—(Professor W. E. Ayrton, F.R.S., Examiner): "The answers to the questions set at the recent Technological Examinations in Electric Lighting and Transmission of Power show that the candidates, with a few striking exceptions, have hardly advanced beyond the mere descriptions of the construction of machines, and have had little opportunity of studying the science underlying their trade. Considering, however, how very difficult it is for students to find men who are competent, and who at the same time have sufficient leisure to teach, the answers in this subject may be regarded as fairly good." Our duty to the public compels us most reluctantly to say it is essential that no professor should act as an examiner. There are few who realise more than we do the great ability and energy of Professors Armstrong, Ayrton, and Perry; but we must distinctly point out that these gentlemen should not be examiners in the special subjects upon which they lecture. It is late in the session to make changes, but the council must make the changes, and should do it at once.

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ELEMENTARY ELECTRICITY.

VII.

When a metal ball is placed inside a closed hollow conductor, and in contact with it, the ball attains the same potential as the conductor. But Cavendish and Faraday showed that, under these circumstances, the ball lost all trace of electrification. Hence we infer that a body which is inside a closed hollow conductor, and at the same potential as the conductor, is unelectrified, and, conversely, a body which is unelectrified and within a closed hollow conductor is at the same potential as the conductor.

Hence, if a body be placed within a closed, or nearly closed, hollow conductor, and be at a potential below that of the conductor, the body must be negatively electrified, and if it is at a potential above that of the conductor it must be positively electrified. Thus, a metal ball in connection with the earth, and placed inside a nearly closed conductor, which is at a positive potential, will be negatively electrified, while if the conductor is at a negative potential the ball will be positively electrified.

If the capacity of the ball be known and also its charge when in connection with the earth, the potential of the conductor can be determined. Thus, suppose that the hollow conductor has a potential V, and that C denotes the capacity of the ball. Then, if unchanged, the ball would have a potential V when placed within the conductor. It must, therefore, receive a charge sufficient to reduce its potential from V to O, that is, it must receive a charge of $-$ C V units. Hence, if $-$ Q denote the charge found upon the ball, we have

$$-Q = -CV, \text{ or } V = \frac{Q}{C}.$$

This method was adopted by Dellman for measuring the potential of the air. A ball, suspended by an insulating (silk) string, was raised to the point at which it was desired to measure the potential of the air. The ball was then connected with the earth for an instant, after which it was again insulated, lowered, and its charge determined. The capacity of the ball being known, the potential of the air around it at the instant when it was connected to the earth could be determined as above.

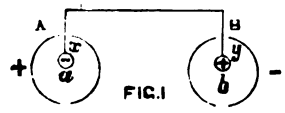

FIG.1

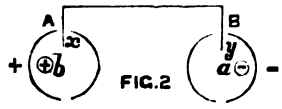

FIG.2

Suppose A and B to be two metallic vessels closed, except for small openings at the top and bottom, and $x\ y$ a wire, whose ends are within the vessels, but which is insulated from A and B. Let $a\ b$ be two small conductors, which can be moved as desired by means of small insulating handles, not shown in the figure. Let there be a small difference of potential between A and B, and for the sake of simplicity suppose that the potential of A is v and that of B $-$ v. First, suppose that a and b are in contact with the ends of the wire $x\ y$, as in Fig. 1. Then, if a and b were unelectrified, a would have the potential v, and b the potential $-$ v. But a and b must be at the same potential since they are connected by a wire. Hence a must be negatively electrified, and b positively electrified. If the capacities of a and b be the same, and are denoted by c, the charge upon a will be $-$ $c\ v$ units, and that upon b will be $c\ v$ units. Now, let a be removed from A and brought into B, and, at the same time, let b be removed from B and introduced into A, as in Fig. 2, and let b be made to touch A, and a to touch B. Then b and a being in contact with the interior of nearly closed hollow conductors will become completely discharged, and the vessel A will receive a positive charge from b, thus increasing its own charge and raising its potential, while B will receive a negative charge from a, increasing its own negative charge, and the numerical value of its potential. The vessels A and B are called inductors; the small bodies a and b are called carriers. If the capacity of each inductor be n times that of each carrier the charge and potential of each inductor will be increased numerically by the operation just described in the ratio of $1 + \frac{1}{n} : 1$ or of $n + 1 : n$.

After the carriers a and b have been discharged, they may again be connected with the ends of the wire $x\ y$, and the whole operation repeated as often as we please, the numerical values of the charges and potentials of each conductor being increased in the ratio of $n + 1 : n$ by each operation. Thus, the charges and potentials increase in a geometrical progression whose common ratio is $\frac{n+1}{n}$. This increase may be continued until the loss due to imperfect insulation, brush discharges, &c., begins to lower the rate of increase, and at length the rate of loss due to such leakage will become equal to the rate at which electricity is furnished by the apparatus, and then all further increase will cease.

The replenisher of Sir William Thomson is identical in principle with the apparatus just described. It consists of two insulated inductors, A and B (Figs. 3 and 4), usually made of brass, and together forming a hollow cylinder except for two spaces, by which the inductors are insulated from each other, and two brass carriers, a and b, supported on an ebonite arm, which is capable of rotation about a vertical axis, O. There are two springs, x and y, which are touched by the carriers when in the position shown in Fig. 3, and which are connected by a wire passing underneath the carriers, and not shown in the figures. There are also two springs, s and t, attached to the inductors, and touched by the carriers when the latter are as far as possible within the inductors.

Suppose, as before, that there is a small difference of potential between A and B, and that A is at the potential v, and B at the potential $-$ v. Let the inductors be in contact with the springs x and y, as shown in Fig. 3. (We shall for simplicity treat the inductors as though they were closed surfaces. This is obviously far from the case, but Sir William Thomson has shown that a small body placed near the bottom of a hemispherical bowl is under conditions differing very little

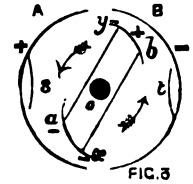

FIG.3

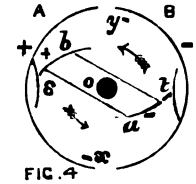

FIG.4

from those of a body placed within a closed conductor. The ultimate effect of the want of closure of the inductors A and B will be merely to diminish the rate of increase of the charges, and will not affect the character of the action.) Then a will be negatively electrified and b positively electrified, since they are in connection with one another, and, if unelectrified, a would have a positive potential (nearly) equal to v, and b a negative potential nearly equal to $-$ v. Now, let the arm supporting the carriers be made to rotate about the axis O in the direction of the arrows. The carrier b, with its positive charge, will then enter the inductor A, and the carrier a, with its negative charge, will enter B, as shown in Fig. 4. Presently the carriers will come into contact with the springs s and t, and thus being in connection with the inductors, while they are also within them, the carriers will give up their charges to the inductors with which they are in contact, the carrier b giving its positive charge to the inductor A, which is already positively electrified, while a gives its negative charge to increase that of the negatively electrified inductor B. After leaving the springs s and t, the inductors, now unelectrified, come in contact with the springs x and y, when a becomes positively electrified and b negatively electrified. The carrier a with its positive charge then enters the inductor A, while the carrier b enters the inductor B, and the operation just described is repeated. Thus, the instrument performs a com-

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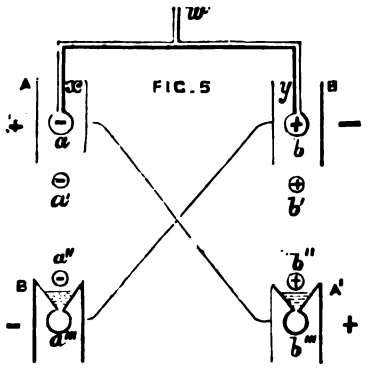
plete cycle of operations twice during every revolution of the carriers, the charges of the inductors being increased in geometrical progression, as in the apparatus before described.

As the carriers pass from one inductor to the other *work* has to be done against the electric forces, for the positively-electrified carrier is leaving the negative inductor which attracts it, and entering the positive inductor which repels it, while the negatively-electrified carrier is similarly being compelled to move in opposition to the forces which act upon it. The work thus done against the electric forces is the equivalent of the increase of energy of the electrified system.

If the ebonite arm be turned in the opposite direction, the carriers which have become electrified by contact with the springs *x y* will be put in communication through the springs *s t* with the inductors, which are electrified in the opposite way to the carriers. Thus the negatively electrified carrier, leaving the spring *x*, will come into communication with the positive inductor A, while the positively-electrified carrier will come into communication with the negative inductor B, and the charges of the inductors will thus be reduced. During this operation the carriers will be moving in the directions in which the electric forces urge them, work will be done by the electric forces, and the energy of the electrified system will be reduced. If the friction could be made sufficiently small the carriers would, when left to themselves, revolve in the opposite direction to the arrows under the the action of the electric forces, thus reducing the charges of the inductors, so long as any considerable differenee of potential existed between the inductors.



Of course it is not necessary that the inductor B should have a potential as much below that of the earth as the potential of A is above it. If the springs *x y*, and the wire connecting them be insulated, the potentials of the inductors may be any whatever to commence with, and the motion of the carriers in the direction of the arrows will increase the difference between them if any exist.

The object in view in designing the replenisher was not to obtain large charges of electricity at the most rapid rate possible, but to increase slowly and almost continuously the charge of a Leyden jar, stopping the increase as soon as the proper limit was reached, and also, in case of over-stepping the limit, to be able to reduce the charge slowly and in an almost continuous manner. These conditions the instrument completely satisfies.

Varley's machine is similar in principle to the replenisher of Sir William Thomson, but preceded the replenisher by several years. The machine was intended for the rapid generation of electricity at high potential. Hence several pairs of carriers were employed, and these, in the form of pieces of tinfoil, were arranged around the circumferenee of a revolving disc of ebonite, while the inductors almost completely surrounded the carriers when the latter were within them.

Fig. 5 represents Sir William Thomson's water dropping accumulator with crossed conductors. In principle it is the same as the replenisher, or the apparatus represented in Figs. 1 and 2, modified only in order that advantage may be taken of the action of gravity upon falling drops of water. Each of the inductors consists of two metal cylinders A A′ and B B′, the cylinders A′ and B′ being provided with small copper funnels, which catch the falling drops of water before allowing them to flow through the small perforations at the bottoms of the funnels. The cylinders A and A′ are connected with a wire so as to form one conductor, and the cylinders B and B′ are similarly connected, but A A′ and B B′ are insulated from each other. A convenient mode of supporting the cylinders is to suspend them by silk twist which has been steeped in melted paraffin, and all four cylinders should be separately suspended from a support considerably above A and B, as the portions of the silk between A and B′ and between B and A′ soon get wet and lose their power of insulation. The wire *x y* of Figs. 1 and 2 is replaced in this apparatus by the water pipe *x w y*, which terminates in two jets within the cylinders A and B. The falling drops of water serve as carriers. Suppose that there is a small difference of potential between A A′ and B B′, the former being at potential *v*, and the latter at potential $-v$. As the drops of water *a b* are formed at the extremities of the jets the drop *a* will be negatively electrified, and *b* will be positively electrified. The negatively electrified drop *a* will then fall into the vessel B′ and give up its charge to the conductor B B′, while the positively electrified drop *b* will fall into the vessel A′ and give up its charge to the positively electrified conductor A A′. Thus, the charges of the conductors will be increased in geometrical progression by each pair of falling drops, as in the cases considered previously. The energy of the electrified system is furnished by the work done by gravity on the falling drops against the electric forces, the drops being attracted by the cylinders A and B which they are leaving, and repelled by the cylinders B′ and A′ which they are approaching. Hence, on striking the funnels the drops possess less velocity than if they had fallen through the same distances and no electric forces had acted. When the difference of potential between A A′ and B B′ becomes very great the drops break up into fine spray, and, each particle repelling the other particles, the streams of spray diverge, and, instead of falling into the vessels B′ and A′, they fall outside them. No further increase of potential then takes place.

To charge a Leyden jar by means of the replenisher, or the water dropping accumulator, the inner coating of the Leyden jar is connected with the inductor A, and the outer coating with B.

The instruments described in this paper are sometimes said to act on "the compound interest principle," because the charges of the inductors are increased in geometrical progression.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XVI.

The subject for our present consideration is a capacity test devised by Sir William Thomson, and generally acknowledged to afford more correct results than the ordinary discharge test explained in a former number. In this, as in the latter operation, the cable is regarded altogether as a condenser, and, following the same course pursued in that case, the cable or condenser of unknown capacity is compared with a standard or a condenser whose capacity in microfarads is known. The test by balance, as it is termed, is more complicated than the other, and requires the employment of greater variety of apparatus.

The difference between the two tests may be thus set forth:—In the capacity test by discharge the accumulating quality, or, technically, the electro-static capacity of the conductor (measured by the inductive capacity of the dielectric) in a condenser charged to a certain potential is determined or represented by the amount of deflection produced by discharging it through the coils of a galvanometer, and if we know this capacity, that is, how many microforads it is, we have a standard to which we can compare another condenser, or cable, by trying what deflection it will exhibit when charged to the same potential and discharged through the same galvanometer. Finding that a condenser of, say, $\frac{1}{2}$

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microfarad gives 300 divisions under certain conditions, we have a comparative proportion when getting, say, 320 divisions from our cable or unknown value condenser with the same conditions. In practice, of course, we should use a shunt, but that is merely for convenience, as the reader has long since fully understood. In the capacity test by balance, as its title indicates, the capacities of the known and unknown condensers are relatively ascertained by the difference of potentials at the two opposite poles of the battery being such that, on uniting the condensers (putting them into conductive communication), and so dividing the charge between them, no deflection is produced when they are discharged through the galvanometer coils. Supposing we had two condensers of equal capacity charged from a battery, one from each of its poles, then if one were connected to one end of the galvanometer coils and the other to the other end, no deflection would be produced, because the opposite charges would be neutralised. Similarly, if we joined the two equal condensers thus charged to the same potential and allowed the charges to mingle, on proceeding to discharge them through the galvanometer no deflection would result, since there is no charge left. But if two condensers of different capacities were charged from the opposite poles of a battery, and brought into electrical communication with each other as before, what will be the result when we proceed to discharge them through the galvanometer? By the way, we ought to say that in both cases we suppose the battery disconnected from the condensers before the latter are joined.

The two condensers being both charged from one battery, one from each pole, the quantities of electricity on each must be equal. But the *density* or quantity per unit of surface is not the same for both. When they are joined together there is a redistribution. We should like to consider carefully the various conditions attending the charging and the various changes in connection with this test. But it would occupy too much space, and may be deferred. Briefly summed up the principle is this. The amount of accumulation in the case of charged condensers, and the effects resulting from various arrangements depend on the resistances of the inductive circuits. In the case of two condensers opposed one to the other, as in this balance test, the potentials on either side are regulated by the same cause, and any alteration of the resistances on either side of the battery must affect the potentials, a difference of which can alone produce a deflection on a galvanometer when attempting to discharge the quantity supposed to result from bringing the opposite charges together.

What we have to arrive at in this test is to cause the potentials at the two sides to be equal, so that no deflection shall result, and having unequal capacities on each side we establish an arrangement of resistances which will compensate for the inequality. The potentials each way must be made equal to the product of the quantities and the resistance on that side. We then have no deflection when discharging the united condensers.

Summing up in familiar mode of expression, in the discharge capacity test the cable capacity is found by comparison with the effect of a known capacity, at two consecutive observations. In the balance test the potentials are equalised by addition of sufficient resistance on either side of the circuit. The idea of the steelyard and the scales may be allowed to apply in this conection.

The appliances necessary for this test are, besides the battery and key, a double-current split key, as explained in the joint test, a discharge key, and a high resistance arrangement, either in the form of a box or what is called a slide resistance. As regards the split key, if it were of the pattern suggested in Fig. 31, No. XIV., a stout copper wire must be fixed to join the two sides, in fact, forming an upper bar. The lower bar only is to remain split for the purpose in view. We require two separate connections for the two battery wires, but want also the means for uniting the two end terminals after they have been each temporarily joined to the lower points by depressing the key pieces. The key is shown in figure. By putting both down, whatever are joined to the terminals are charged from the battery, and on releasing them they rest against the bar, and communication results between the charged bodies by means of this latter (or the suggested wire across). The high resistance, if a slide, consists of a set of coils of equal resistance, either of 100 or 1,000 units each, with a contact piece, which can be slid along the face to any point, thus dividing the whole into two parts, and enabling us to connect any desired proportion on either side of a circuit. If the resistance is in the form of a box, the pointer simply turns on a pivot, the coils being ranged in a circle round it. Suppose, in a resistance composed of ten coils of 100 units each, the pointer were turned on to the terminal of the fourth coil, or rather we should say the fifth, because, to make any proper use of ten equal coils, we must have one more terminal or coil of no resistance in addition to the ten; therefore, the pointer in this case being on the fifth terminal, there would be 600 units on one side and 400 on the other, the pointer being connected with earth. The wires joining the coils to the two sides of the circuit would be one at the first coil terminal and the other at the tenth. The idea is roughly shown in Fig. 38, where the coils, whatever their value, are all equal, the first, however, being of zero resistance. We have not space for a more detailed account of the construction at present. The coils being always of considerable resistance, certainly not less than 100 units generally speaking, and never less than ten, the student will observe that by this arrangement there are no intermediate resistances, as tens and units, available for our purpose, whereas in testing the capacity of a cable we may require a very small amount to perfect a balance of potentials; an unit more or less makes all the difference if our instrument is sensitive. There are two ways of supplementing this requirement. In one of these an additional box or slide is connected with the larger resistances, and consists of a set of smaller coils, each being a certain proportion of one of the former.

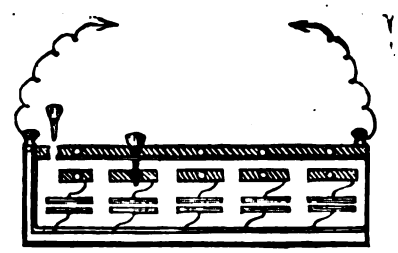

Fig. 36.—Condenser Box.

The learner may know what a "vernier" is on a measuring scale, and will see how this is made to serve the purpose. If there be no such convenience at hand an ordinary resistance-box may be brought into circuit with one part of the resistance already mentioned, and will enable us to arrange our balance. In a well-furnished testing room the high resistance-box (more convenient than a set of slides) will have its accessory box, and the coils in each will be so arranged that, when in performing the operation we have arrived at a balance, the amount of resistance finally marked by the pointers of the two boxes may be read off on the scale on the face of each. For example, if in the high resistance the pointer stood at 52, and in the smaller box at 38, the amount of resistance would be 5,238, from which we find that on one side we have 5,238, and on the other 4,762, the total being 10,000; this has been the proportionate division found necessary to equalise the potentials on each of the battery poles. Where there is no vernier and an ordinary set of coils is employed as just stated, we have only to add the smaller units to the larger, but the arrangement is not so complete.

We will now trace the course of the operation by the aid of Fig. 37, in which are represented the connections for the test in sufficient detail. The condenser, whose capacity in microfarads, of course, is known, is connected to one terminal of the split key, and the cable, whose capacity we want to know, is joined up to the other. The object is to charge the condenser (our standard measure) and the table separately, but exactly at the same instant, for a certain period, say, a few seconds, then to cause the charges to mingle by releasing the key pieces which

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strike against the upper bar. The *plus* and *minus* charges are in this way divided according to the relative capacities of the condenser and cable. We have then to discharge the whole through the galvanometer, when, if the potentials are equal, no deflection will appear on the scale. Starting from the battery the positive charge will enter the condenser, and the negative charge will pass to the cable. Let the keys be kept down five seconds. At the end of this time they must be released. As both now rest against the upper bar the two end terminals now also connect with it, and through it the charges of condenser and cable amalgamate. If exactly equal they are neutralised. If, as nearly always happens, the cable charge (here *minus*) preponderates, the whole of the *plus* charge is destroyed, but some *minus* charge remains. This is not ascertained until, by depressing the discharge key the remaining charge passes by the lead wire to the galvanometer, and is discharged through it to earth, causing a deflection, right or left as the case may be. The deflection shows that there is a difference of potentials at the two sides of the galvanometer, and of the battery poles, of course. We know from this that the resistances have not been adjusted correctly, and the operation must be repeated after altering them. It is evident that the test will be long and tedious or otherwise, according to the correctness of this adjustment, and it will also depend on other points which must be carefully attended to. In the first place, the relative capacities of the condenser and the cable are matters of interest; we do not know the exact capacity of the latter, but it can be approximately estimated. The average capacity per knot is on record, and, knowing its

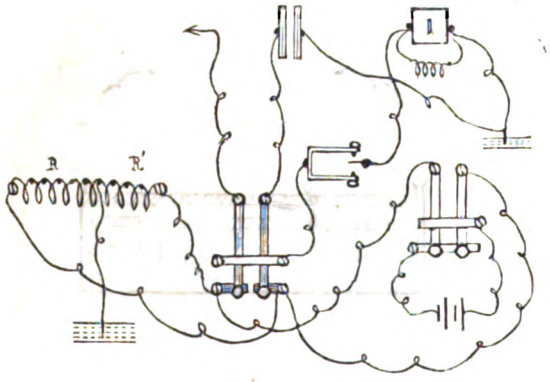

FIG. 37.

length, the total capacity is got at pretty nearly. If it be a very short length we could choose a condenser having nearly the same capacity. The amount per knot is generally $\frac{1}{3}$ microfarad; thus for a length of 10 knots we should choose a condenser of 3 microfarads. When very long sections of cable are in question we can only choose a condenser of a submultiple of its capacity; for 400 knots we might use a condenser of 40 microfarads, if we had one. The object in having a convenient submultiple is, of course, for the adjustment of the resistances.

Another important point is the determination of the amount of resistance to be introduced on each side. It should be noted that the larger these are the better for the purpose, as, if otherwise, the difference of potentials would be insufficient to enable us to measure resistances on the galvanometer. Having, then, a set of the highest coils available, the question arises—on which side is the largest resistance to be introduced? We determined this by observing which of the two—namely, the condenser or the cable—has the larger capacity. Seeing that the difference between that of the two is to be equalised by the addition of resistance on the lesser side, it is clear that if, as is usual, or as it is best to assume, the cable has a larger capacity, the smaller resistance must be inserted on the cable side. For the capacity of the condenser (known), multiplied by the resistance on its side (known), will equal the resistance on the cable side (known), multiplied by the capacity of the cable which we are seeking; that is to say, this is the case when the adjustment has been so made as to cause no deflection when the two are discharged through the galvanometer. One more point is worth mentioning. It is well to know beforehand whether the positive or the negative charge would deflect the spot to the right or left hand. Circumstances often disturb the operation so as to render it doubtful whether the addition or reduction of resistance in attempting to get a balance has really caused the movement in either direction. The effect of the *plus* or *minus* charge, therefore, will then be ascertained by means which, of course, the learner will find no difficulty in adopting. Having arranged these preliminaries, and taken care to connect the earth wires to the proper terminals of the resistance box and the condenser, the test may be commenced. Supposing there is no second resistance box, which we have compared to a vernier, a set of coils for varying the smaller quantities, as tens and units, will be in circuit between the larger set and the split key. The best way to take the test is to use alternate currents; and, even if the first trial, say with the negative battery key down, should prove successful, a second with the opposite pole would be necessary, as the result ought to be the same with both. In the figure the cable is connected to the negative pole when the right-hand key piece is down. The split key is often constructed with a cross piece of ebonite uniting the two key pieces, so that a single pressure puts down both exactly together, which we observe is very important. It is not always quite certain that both are put down exactly at the same instant, though a finger be placed on each, and the same when they are released. A shunt will be useful in any case, and it will be safest to use the largest at the outset; that is, to put the plug in the 1,000 place, the shunt box consisting of a set appropriate to the galvanometer, as explained in an early number, and with coils of 10, 100, and 1,000. By this means the effect on the galvanometer is reduced 1,000 times, $\frac{1}{999}$th only of the current going through it. When a trial or two shows that the balance is near being attained, the others may be used in turn, and finally no shunt, the plug being altogether removed. We will now depress the right hand key and clamp it down. No charge can result while the split key terminals are disconnected from it, but on depressing both key pieces together a charge enters by these terminals both cable and condenser, and will charge each according to the potentials established by their several capacities, and by the resistances on either side of the battery poles. This is allowed to last for five seconds, when the key pieces are released. Then, after five seconds more, during which the charges are mingling, if the discharge key is touched down, and the spot at the same time observed, a deflection right or left will most probably appear. We have now to determine whether to add or reduce on the side on which we have the variable resistance. This depends on which pole originated the charge which caused the deflection. We have previously found this out, and can, therefore, tell whether there is too much or too little in circuit on either side. Of course, whatever we add on one side reduces the other relatively, and *vice versâ*. We must estimate the amount to be inserted or removed, and try over again, but with the other battery pole to cable. In making this reversal the discharge key should be kept down without being released from its last depression, the object being to prevent any interference with the proper discharge of the condenser and

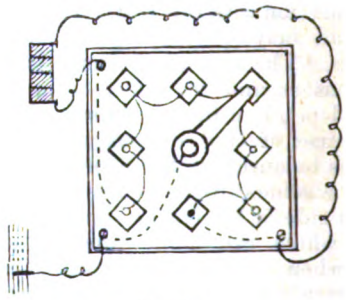

FIG. 38.

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cable. The operation is repeated with alternate currents until no deflection is produced, when, supposing the last charge in the cable had been, say, positive, one more reversal is to be made, to see if the balance is true with both currents. If so, the capacity of the cable is found by the proportion:—The capacity of the condenser : the resistance on the cable side :: the capacity of the cable : the resistance on the condenser side. Whence the capacity of the cable = the capacity of the condenser × the resistance on its side ÷ the resistance on the cable side. The resistance is in microfarads. We have gone through the test in its complete form, as performed when operating on a submerged cable. At the works, and with short lengths, it is not usual to employ alternate currents. Of course, both *plus* and *minus* charges are in action either way, but the latter only, as a rule, is used for the cable charge. In concluding our remarks on this test for the present, we would point out that in saying the capacity per knot of a cable is about one-third of a microfarad, we speak of it under the unit potential, that is, 1 *volt*, nearly one Daniell cell. We have before observed that capacity is not arbitrary, but must be understood as being of a certain potential. When we use battery power of one volt (say one cell) a knot of cable has a charge of one-third microfarad, but with 120 cells it would have a charge of 40 microfarads. The condenser, however, with which we compare it is credited with so much capacity of unit potential, and that of a cable is related to it as to a general and uniform standard.

The condenser box in Fig. 36 is a convenient arrangement for combining several condensers in a small compass. One of the terminals of each connects with an earth terminal, and the other poles each connect with a brass piece, which can be joined at will to the line terminal by inserting a plug. Any number can be used from 1 up to 20, and, all combined, equal 40 microfarads. In Fig. 38 we have a sketch of a resistance box for dividing the amount on either side of the battery poles. The figures are sufficiently explanatory.

A DYNAMO-ELECTRIC MACHINE.

BY M. J. F. PLUCKER.

The following paper has been abstracted from the *Révue Universelle des Mines*, &c., for September and October, 1882.

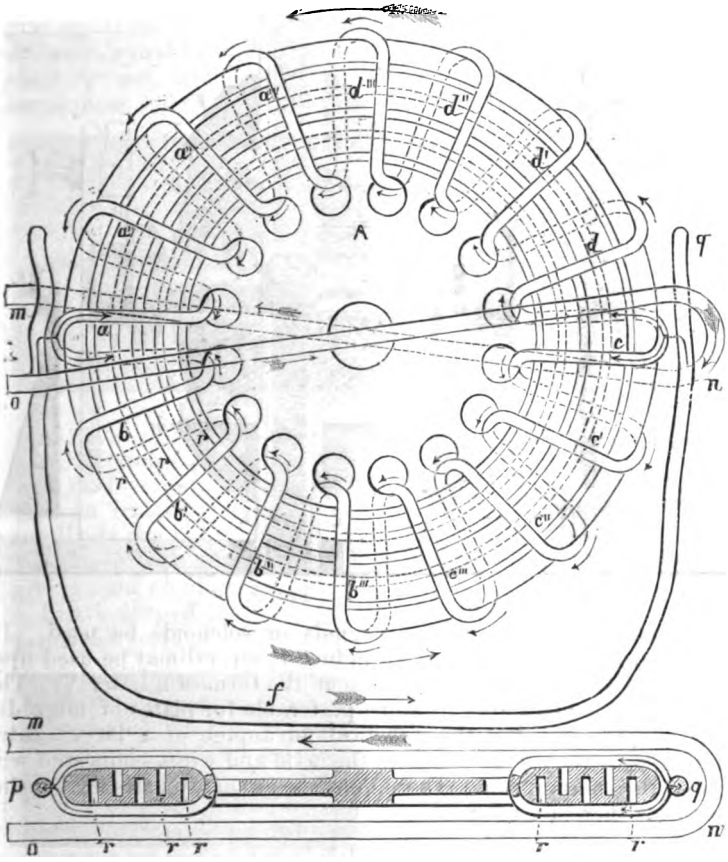

FIG. 1.

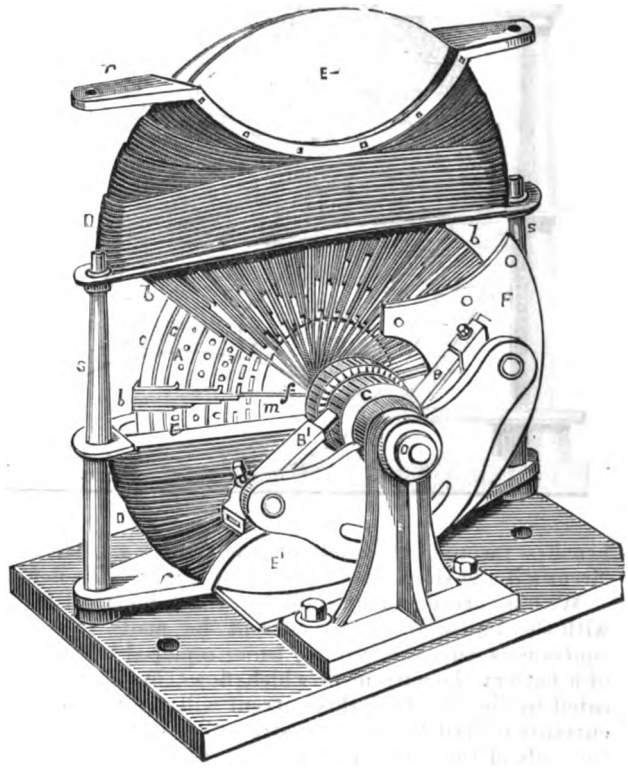

FIG. 4.

The note was communicated by the author to the Antwerp section on May 4, 1882. Although we have not seen one of these machines, we know that a good deal of work has been done in the direction of disc machines, of which this is a type, and it is, therefore, well that the historic continuity of the work in this direction should be placed before our readers. The note is divided into two parts, the first dealing with theory, the second describing the machine. Then, first:—

THEORETIC CONSIDERATIONS.—In Fig. 1, let A represent a disc of soft iron movable around a central axis. This disc may support an insulated copper wire $a\,a'\,.\,.\,b\,b'\,.\,.\,c\,c'\,.\,.\,d\,d'$, wound helically around the periphery of the disc. Further the disc is surrounded by a horizontally wound coil, $m\,n\,o$, connected to a source of electricity, so that the current goes in the direction of the arrows. Under these conditions if the disc is rotated in the direction shown by the large arrows, currents are produced inductively in the continuous wire $a\ b\ c\ d$ in directions which accord with Lenz's law. Thus in the parts $a\,a'\,a''$, upon the front of the disc, approaching the inducing current $o\ n$, the induced current will be of contrary sign to that of $o\ n$, and in a direction from the centre towards the circumference, while the parts $a\,a'\,a''$ upon the back of the disc will have currents of opposite sign to $m\,n$ and in direction from the circumference to the centre; they will increase the potential of the first named currents $a\,a'\,a''$. The portion of the wire on one side of the disc is only influenced by the portion of the inducing current which affects that side, for the disc intercepts, during its magnetisation, the lines of force coming from the opposite side. On the other

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hand, in the parts *b b' b''* on the front of the disc, which are distant from *o n*, the currents induced will have the same direction as *o n*, and travel from the circumference to the centre. Similarly, the current induced in the back parts *b b' b''* will be of the same sign as *n m*, and will join the currents *b b' b''* in the front. The induced currents produced in *c c' c''* at front and back, and in *d d' d''* at front and back, will add to the potential of the other currents as follows:—The first named to that of *b b' b''* front and back, and the second to that of *a a' a''* front and back. Thus, all these currents go to form two principal currents of opposite sign, the one traversing the upper half of the front of the disc from the centre to the circumference; the other traversing the lower half from the circumference to the centre. These currents become one quantity current when two previously bared points in the continuous wire are connected by a wire *p q* (see horizontal section, Fig. 1);* this conductor should remain in contact with the continuous wire during rotation of the disc; in this way a continuous current will be maintained in it.

The current will evidently be greater and more constant according as the number of coils in the inducing and induced circuits are greater. Therefore, to obtain the greatest effect, the simple coils of continuous wire, shown in Fig. 1, should be replaced by coils arranged like those in a Pacinotti or Gramme ring, that is to say, connected to one another and to the sectors of a Gramme commutator, on which rub two brushes forming the ends of the wire *p q*. The inducing circuits *o n m* should be replaced by a multiple solenoid.

With an arrangement similar to that shown in Fig. 1, and with the disc at rest, if a current be made to traverse the continuous wire, the wire *p q* being replaced by the terminals of a battery the current of which flows in the direction indicated by the arrows *f*, this current will split near *n* into two currents of half the original strength, and these will traverse the coils of the continuous wire in the direction of the induced currents mentioned above, uniting again at *s* to return to the battery. These two currents will act by attraction and repulsion on the current *o n m*, and it is easy to ascertain, by applying Lenz's law, that these reactions will unite to rotate the coils and the disc in an inverse direction to that indicated by the curved arrows. The machine is, in fact, reversible; that is, it can act as a motor or generator.

DETAILS OF THE MACHINE.—A is an iron disc, having grooves pierced with slots, M M, and holes, *t t*, which are utilised for the winding of the coils *b b*. These coils are wound step by step, as shown, so as to cover the face of the disc as completely as possible. The ends of all the wires are carried to the axle O, where they are united in a tubular-shaped bundle, carried through the inducing solenoid D D', and then connected to the sectors of the commutator C'.

Two brushes, B B, rest upon the commutator, and collect the current generated. Rotation is obtained by means of a band upon the pulley *p*. Two soft iron plates, coiled with wire from the inducing solenoids D D, attached to which are two cast-iron wires, *r r'*, a space being left between the solenoids for the axle. The coils are held in position by the iron posts *s s*. Four iron plates, E E' E'' E''', are fixed to *r r' r'*, the whole being retained in position by the pieces F F' F'' F'''. These plates act as magnets, as will readily be understood by considering Fig. 3. At the first onset with this machine it is necessary to have a current from an external source. Afterwards the residual magnetism of the plates E E' E'' E''' suffices.

The inducing solenoid may be replaced by horseshoe electro-magnets, each pole of the latter having a surface equal to three times that of the disc, the arms being wound with wire of the same section, and having a total weight equal to that of the wires constituting the solenoid. It has been found that the results obtained with the solenoid or the horseshoe magnets are sensibly equal, but the solenoid has the advantage of being lighter, and occupying less space.

The machine is stated by the author to act fairly well as a motor, whether electro-magnets or solenoids be used. Instead of a single solenoid inductor, several may be used upon the same plate by giving them the form of a letter V. This arrangement appears to be preferable for plates of large diameter, and has the practical advantage of a large central space for the passage of the axle and wires connected with the commutator. There must be as many pairs of brushes as there are solenoids.

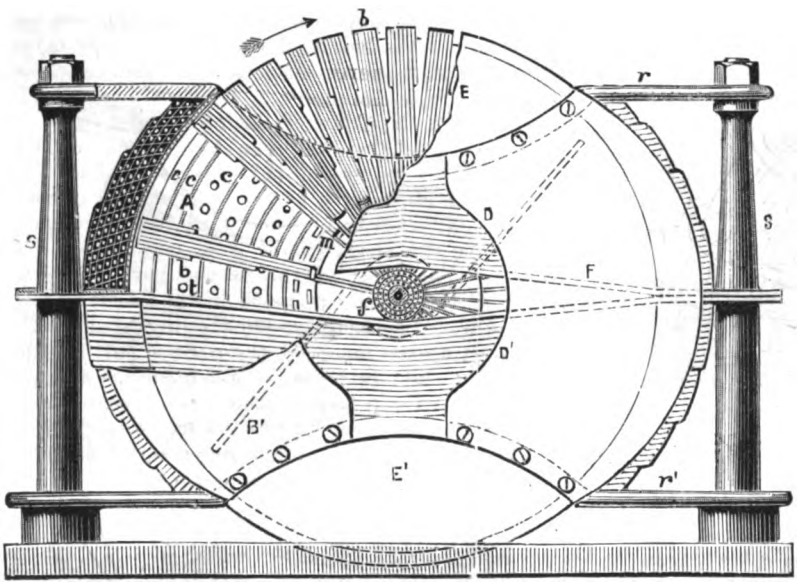

FIG. 2.

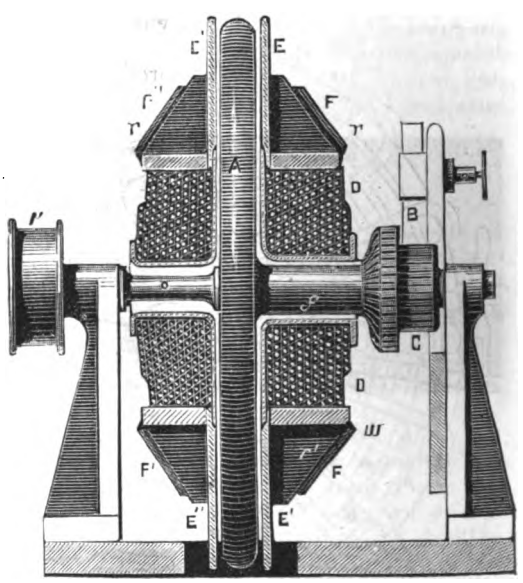

FIG. 3.

* It is only on making connection between these two points that induced currents will be produced during the rotation of the disc; for the effect of the inducing current *o n m* on each half of the continuous wire, above and below the horizontal diameter, being equal and opposite, keeps the induced current in a state of equilibrium, whilst it causes a difference of potential between two points situate on the same diameter, which difference attains its maximum at the horizontal diameter, and becomes *nil* at the vertical diameter.

THE DISTRIBUTION OF LIGHT.

BY J. T. SPRAGUE.

Every one knows that the law of the distribution of light is that it varies as the square of the distance from its point of origin; but it is doubtful how far this law is realised. The reason of the law is purely physical, and it assumes that the strength or intensity of light is subject to the law of quantity. The contents of a sphere, for instance, vary as the cube of the radius or diameter. If, then, we dissolve the same quantity of any substance in the water contained in two spherical vessels, one having double the diameter of the other, the solution in the larger will have only one-eighth the strength of that in the smaller, because the substance is diffused in $2^3 = 8$ times the quantity of liquid. But if a substance is propelled in equal spreading films from the centre

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of a sphere, it would be no longer diffused in the whole space, but would be successively spread over the enlarging surfaces. Now, the surfaces of spheres enlarge as the square of the diameter, and, therefore, if we spread the supposed equal quantities of substance over the surfaces of our two supposed vessels, the strength of the two films would be as 1 to 4—that is, the diameter being doubled, they would be 1 to $2^2 = 4$.

This is the condition of the propagation of light, which, issuing from a central point, is spread over successive spheri-

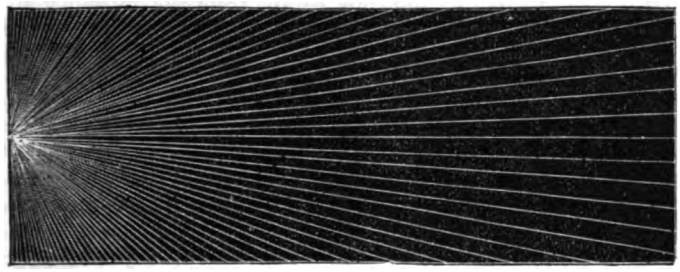

Fig. 1.

cal shells, at each of which the area being as the square of the distance from the centre, the quantity at each point or unit of area must be inversely as the square of this distance.

The practical effect is that as distance increases the power of the light must increase as the square of the distance to give equal effect; that is, if we wish to have light at 10 feet distance, equal to that of a candle at one foot distance, we shall require 100 candles to produce it, but on the other hand these 100 candles will give that light over a spherical

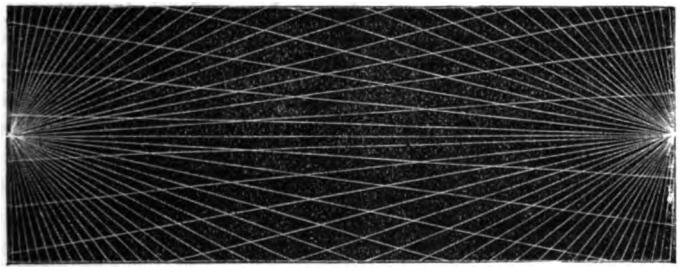

Fig. 2.

area 100 times as great. For most purposes an illumination evenly distributed over a large area is of more value than an irregular light of greater power, and it is better to subdivide the light and distribute it in several sources, which has the further advantage of breaking up the shadows, and giving light on all sides.

I have devised the accompanying diagrams to present these principles to the eye. In Fig. 1 a powerful light is shown at

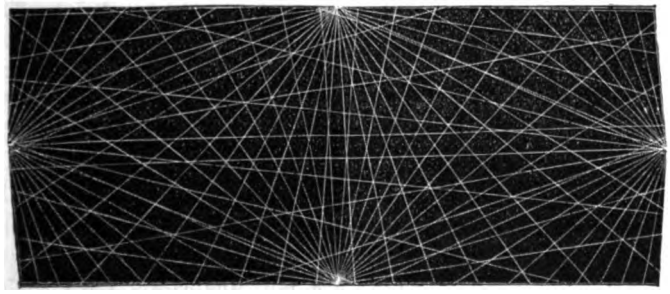

Fig. 3.

one end, and the gradation of the effect according to distance is evident.

In Fig. 2, two lights of half the strength are opposed, so as to equalise their actions.

In Fig. 3, the light is divided into four for the same purpose.

The intention is to show the effect of an equal quantity of light thus divided, and to effect this, each diagram contains the same number of radial lines representing the light. Of course, the intention can only be very imperfectly carried out, because the primary action is generally modified by reflections from walls and ceilings. But this does not materially affect the result, because such reflections themselves operate under the same laws as the direct radiations.

SPECTROSCOPIC EXPERIMENTS WITH THE ARC.*

BY PROFESSORS LIVEING AND DEWAR.

The concentration of the radiation of hydrogen in a small number of spectral lines would lead us to expect that the absorption of light of the same refrangibility as those lines would, at the temperature of incandescence, be correspondingly strong, and that, therefore, the hydrogen lines would be easily reversed. The mass of hydrogen which can be raised to a temperature high enough to show the lines is, however, so small that, notwithstanding the great absorptive power of hydrogen for the rays which it emits, the reversal of the lines has not hitherto been noticed. In fact, the lines are very readily reversed, and the reversal may be easily observed.

When a short induction spark is taken between electrodes of aluminium or magnesium in hydrogen at atmospheric pressure, a large Leyden jar being connected with the secondary coil, the hydrogen lines show no reversal; but, if the pressure be increased by half an atmosphere, the lines expand, and a fine dark line may be seen in the middle of the F line. As the pressure is increased, the dark line becomes stronger, so that at two atmospheres pressure it is very decided. As the F line expands the dark line expands too, and becomes a band. It is best seen when the pressure is between two and three atmospheres; at higher pressures it becomes diffuse, and at five atmospheres it can hardly be traced. No definite reversal of the C line is observed under these circumstances, at least with the one prism spectroscope employed.

By using greater dispersion, the reversal of both C and F may be observed at lower pressures. For this purpose the authors used a Plücker tube, filled with hydrogen, and only exhausted until the spark would pass readily, when a large jar was used. The light of the narrow part of the tube is then very brilliant, while the spark in the broad ends of the tube is wider and less bright. On viewing such a tube end on, and projecting the image of the narrow part of the tube on to the slit of the spectroscope, a continuous spectrum of the width of the narrow part of the tube is seen along with the lines of hydrogen given by the discharge in the wide part of the tube. These lines extend above and below the continuous spectrum, and produce a distinct absorption where they cross it.

The authors (*Proceedings* Royal Society, Vol. 30, p. 157) have observed that the C and F lines of hydrogen are visible in the arc of a De Meritens machine taken in hydrogen; though, in the arc of a Siemens machine the C line can only be detected at the moment of breaking the arc, the F line hardly at all. When, instead of taking the arc in hydrogen, small drops of water are allowed to fall from a fine pipette into the arc taken in air inside a lime crucible, each drop as it falls into the arc produces an explosive outburst of the hydrogen lines. Generally the outburst is only momentary, but occasionally a sort of flickering arc is maintained for a second or two, and the hydrogen line C is visible all the time. The lines (C and F) are usually much expanded, but are frequently very unequally wide in different parts of the line. F is weaker, more diffuse, and more difficult to see than C, and is visible for a shorter time. There is no sign of reversal. In the explosive character of the outburst and the irregularity in the width of the lines the effect resembles that of an outburst of hydrogen in the solar atmosphere. The elements of the water are, as it must be supposed, separated, but from the explosive character of the effect they are not uniformly distributed in the arc. The arc being horizontal, and the image of it projected on to the slit of the spectroscope, it was really a very small section of the arc which was under observation, and this renders the variation in width of the lines the more remarkable.

* Abstract of a paper read before the Royal Society, March 8, 1883, entitled "Note on the Reversal of Hydrogen Lines, and on the Outburst of Hydrogen Lines when Water is Dropped into the Arc."

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ANSWERS TO CORRESPONDENTS.

J. P., Gloucester.—You can purchase the apparatus from any of the electrical apparatus makers, such as Clark, Muirhead, and Co.; Elliott Brothers, Johnson and Phillips, &c.

W. T. F.—Shall be glad of your proposed paper; also of any further information with regard to arc lamp in use thirty to forty years ago. The Duboscq (not Buboscq) arc lamp was an improvement on the Foucault lamp; it was one of the earliest arc lamps, and was used at the Opera House, Paris, where M. Duboscq was electrician.

J. G. and others.—We shall always be glad to receive information concerning electric lighting work. Clark's gas lighter, and we believe his induction coil and battery, are made by Messrs. Strode and Co., Osnaburgh-street, N.W.

ELECTRICAL TRAMWAYS.

The problem of electrical locomotion possesses extreme interest for the public at large, and for metropolitan inhabitants especially, just now. To the latter anything that may lend additional force to the protest against experimentally ventilating a public drain, so to speak, into private dining rooms, which is being ostentatiously tried by a London Underground Railway Company would be heartily welcome; whilst to those with whom overtaxed horses are objects of compassion, any hope of ameliorating their sufferings will be highly acceptable. It is notorious that subterranean railway travelling is extremely unwholesome; it ought to be equally notorious that subterranean railways need not be unwholesome. They are dangerous, too, by reason of accumulated steam obscuring the signals; whereas they need not be dangerous at all, for the steam could be condensed if the necessary outlay were incurred. And even if this failed there are other modes of progressive locomotion besides that involving the the use of steam locomotives. Electrical railroads, failing all other expedients, promise an escape from the nuisance and risk attending these now indispensable luxuries of urban locomotion, and the public are anxiously waiting to see this promise fulfilled. As regards tramways, the destruction of horseflesh, caused, it would seem, by the unavoidable strain at every fresh start, is not only very costly but very cruel, and there is an urgent demand in this quarter for something that shall at once relieve the horses from an unnatural effort, and the shareholders' pockets from an oppressive tax.

For all these reasons, and more that might be named, the public are curiously listening to what is now being said about the generating, storing, and transmission of electrical energy, more particularly as touching the matter of locomotion. Naturally, the first serious experiments of a practical kind have been made on the tramcar; at Berlin a considerable length of tramway has actually been working, and we believe answers the projectors' expectations. We need hardly say that the tramway alluded to is not worked by storage batteries. There is a great future before the storage battery, we are assured on very high authority, and we quite believe it, only perhaps we differ as to the character of its greatness and the distance of its future. Still, we are interested in every experiment made with this much-abused system, and sincerely admire the indomitable energy of the people engaged in promoting it. Last Saturday a trial was made on the tramroad between Kew and Uxbridge-road—a trial in which the battery of one of the companies which have taken up the storing of electricity for commercial purposes was put to the test as a substitute for horse-power. From one point of view it was not a success, but as drawing attention to the subject, and as pointing the obstacles that have yet to be overcome before complete success is achieved, the result was as good as could be desired.

Except as a public advertisement—we use the word in its broadest sense—the trial was, indeed, hardly worth making, for a similar one had already been made at Paris, and a satisfactory trial had been given to the system here over the Acton line for the benefit of the Board of Trade officials. The trial on the Kew line was not so successful, owing to the car not being adapted to the change of gauge, which, though comparatively small, was sufficient to cause the rails to act as an effective break on the wheels.

Glancing over the public announcement of the company in question, however, we are struck by the aptitude of the authors for turning figures to useful financial account, and their apparent inaptitude for appreciating precisely those practical difficulties which are not financial. Each horse-power of the steam engine, the public are informed, costs a halfpenny per hour; the electricity stored amounts to 50 per cent. of the energy expended, and will cost, therefore, one penny per hour. This gives as the total cost six shillings per working day, against twenty-six shillings—we quote the figures before us—expended on animal horse-power at present. There is left, therefore, a big margin for intending investors. What is left for the batteries themselves is not stated, for the reason, perhaps, that nothing is yet certainly known as to the life of these mysterious agents. And yet,

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when speed and certainty have been thoroughly attained, which can hardly be said to be the case as yet, cost of maintenance and renewals is everything, and this is not covered by what the prospectus euphemistically calls "depreciation" and "contingencies." We are bound to look at the worst side of all electrical applications, and to point out conditions that do not seem to have been sufficiently considered.

One of the most encouraging features of this gathering was the speechmaking. Fully reported they are calculated to have an inspiriting effect upon what Mr. Edison calls "my stockholders." From the scientific point of view, unfortunately, their value is somewhat diminished by the circumstance that they were delivered before the trial was made, not after. Dr. Siemens being present, he was described as a person who knew a little about electricity, a joke which provoked much laughter, and which was justified by his own speech immediately after, in which he dilated fluently upon electricity, but reservedly on the subject of storing it. Another speaker stated that one of the greatest difficulties the company had to contend with was the storage department, a remark which, if not meant as a contribution to the facetiæ of the occasion, had certainly the merit of being droll. On the subject of electrical locomotion generally, however, some sensible and instructive observations were made, and these especially may have a wider circulation, we trust, and exert more influence on public opinion than the particular occasion of their delivery perhaps entitled them to. The transmission of power is said by Mr. Edison to be far more profitable than the providing of light, and it has so often been remarked that something was wanted to enable man to use the now wasted natural powers existing to an enormous extent, that there is far greater real interest and thought given to this application of electricity than is ordinarily understood.

GUSTAVE TROUVÉ.

Sterne's theory of the influence of names upon pursuits is certainly borne out by the case under notice. Surely never was a happier name for an inventor than Trouvé (found), almost a literal translation of the Greek sage's exclamation "Eureka!" on making his grand discovery.

M. Gustave Trouvé, whose portrait is appended, was born at Lahaye-Descartes, in the Department of Indre-et-Loire, France, on January 1, 1839, his family being well and honourably known in Touraine, although not connected with scientific investigations. From his earliest years young Trouvé showed great aptitude for drawing, mathematics, and mechanical work. At the age of seven, with the aid of some hair-pins and pieces of metal, he made a working model of a steam engine, with an old powder canister for boiler. Commencing his studies at the Chinon College, he afterwards followed the curriculum of the Ecole des Arts et Métiers, at Angers. At the age of 20 he entered the workshop of one of the leading clock and watch makers of Paris. In 1866 M. Trouvé started a small mathematical instrument factory in the Rue Thérèse, Paris, a street which is now demolished. Here his ingenuity of resource and skilful workmanship soon brought round him some of the first scientific men of the day. He was also in constant relations with the leading physicians of Paris. It was at the instigation of one of them, Dr. Gavarret, that he conceived and completed in three days the electrical instrument for determining the position of, and extracting bullets lodged in the human body. This instrument, with the electrical polyscope for enabling surgeons to see into the throat, the eye, &c., of a patient, secured for M. Trouvé, in 1875, the Barbier prize of the Paris Faculty of Medicine; and in acknowledgment of his valuable contributions to the Paris Electrical Exhibition of 1881 he was made Chevalier of the Legion of Honour.

The following is a list, in chronological order, of M. Trouvé's principal inventions:—

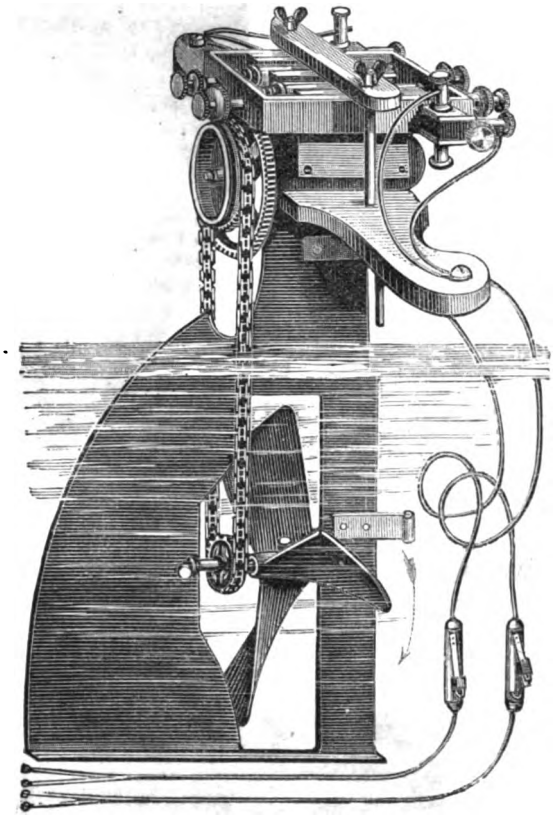
1. Time-piece escapement, beating the second or half-second at pleasure, without the necessity of varying the length of the pendulum.

2. Double-action electro-spherical motor (1864). This motor demonstrates experimentally Newton's law, that action is equal to reaction, and force to resistance. It is now used to demonstrate the reactions which take place in Crookes's radiometer.

3. Hermetically sealed battery, that may be turned upside down (1865). This invention was brought under the notice of the Academy of Science, on December 9, 1867, by M. Becquerel, and before the Academy of Medicine, on June 8, 1869, by M. Béclard. This battery has been applied by its inventor to a large number of special applinaces.

4. Electrical gyroscope (1865), made at the instance of M. Léon Foucault.

5. Electro-medical pocket case for surgeons (1865), brought before the Academy of Science on December 9, 1867, and the Academy of Medicine on June 8, 1869.



Trouvé's Electric Motor attached to Rudder.

6. Apparatus for determining experimentally, and instantly, the best angle of inclination for a screw propeller of given power (1867).

7. Pocket polyscope and electrical polyscope (1869) mentioned above.

8. Electrical explorer and extractor of bullets (1869). This instrument detects the presence, in the tissues of the body, of any substance metallic or non-metallic, and indicates the direction it has followed, its depth, and whether it is covered or uncovered.

9. Appliance for aërial navigation, by means of an artificial bird and a system of two parachutes, brought before the Paris Academy of Science on December 2, 1870.

10. Military telegraph (1870). This apparatus, which may be carried on the back like a knapsack, inaugurated a new system of military telegraphing. It was brought by M. du Moncel before the notice of the Société d'Encouragement, on May 10, 1872.

11. Trouvé-Onimus Appliance (1871), presented by Dr. Gavarret to the Academy of Medicine on January 13, 1874. This appliance, intended for physiological investigations,

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indicates the number of intermittences of an electric current in a second, and affords the means of regulating this number, instantly and at pleasure, correct to a hundredth part of a second.

battery, more constant than that of Daniell, is employed in telegraphy and therapeutics, as well as for electric clocks and the recording apparatus at the Paris and Montsouris Observatories.

Portrait of M. Trouvé.

12. Wet battery and constant and continuous current pparatus (1873), brought before the Academy of Science by M. Becquerel on December 29, 1873, and before the Academy of Medicine by Dr. Gavarret on January 13, 1874. This

13. Dynamo-electrical or magneto-electrical machine (1875).

The "Eureka" at Troyes Regatta. Driven by Trouvé's Motor.

14. Pocket electro-medical apparatus for regulating intermittences, presented in 1876 to the Academy of Science by

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M. du Moncel, and in 1877 to the Academy of Medicine by Dr. Gavarret.

15. Appliance for demonstrating the manner in which muscular contraction takes place, brought by Dr. Onimus before the Biological Society of France on July 6, 1877.

16. Telephone with multiple diaphragms and voltaic arc, brought before the Academy of Science, November 26, 1877.

17. Electrical motor without dead points and capable of being reversed, brought before the Academy of Science on July 5, 1880.

18. Application of electric motor to navigation. A pleasure boat, driven by electricity, was made to easily stem the current of the Seine on May 26, 1881.

19. Electrical tricycle, capable of making 15 kilometres (nine miles) an hour, submitted to the Academy of Science on August 1, 1881.

20. Application of the Trouvé electrical motor to M. Tissandier's balloon, brought before the Academy of Science on August 1, 1881.

Among M. Trouvé's minor inventions should be named his electric bit for stopping runaway horses, his *porte-caustique universel*, and his electro-mobile jewellery.

M. Trouvé also submitted to the Academy of Science, on August 8, 1881, his investigations as to the best conditions for the construction of powerful magnets. He has, moreover, devised a method of electric lighting for domestic purposes, in which candles may be substituted for incandescence lamps, in case the current should fail.

Perhaps the most prominent of M. Trouvé's labours is his application of electricity to navigation, illustrated by the annexed engraving, which represents the electrical boat, the "Eureka," taking part in the Troyes Regatta, on August 6, 1882, and easily distancing a four-oared gig. The electricity is generated by a 6-cell Trouvé battery, in which a winch permits of the elements being more or less immersed in, or completely withdrawn from, the exciting liquid, consisting of 1 part of bichromate of potash, $3\frac{1}{2}$ parts of sulphuric acid, and 8 of water. The current is led through the tiller ropes (which consist of twisted wires, covered with silk and cotton, and encased in an india rubber tube) to the "*gouvernail moteur propulseur*," or combined rudder, motor, or propeller, an enlarged view of which is appended. The Trouvé electrical motor, consisting of a modification of the Siemens coil, is placed in the rudder head, while the propeller revolves in a slot in the rudder itself, motion being communicated by an endless chain. This arrangement intensifies the action of the rudder, so that the boat can turn almost on its own centre, thus rendering a reversing motion unnecessary. The tiller ropes are provided with contacts, so that the steersman can instantaneously stop and start again. By taking off the rudder, which can be carried under the arm, the boat is deprived of its means of propulsion, a useful quality in the exploration of new countries. The facility with which his electric boat can be manœuvred was practically demonstrated by M. Trouvé on the basin of the Palais de l'Industrie during the Electrical Exhibition of 1881, and we may add that more than three hundred boats on this system have been constructed in two years.

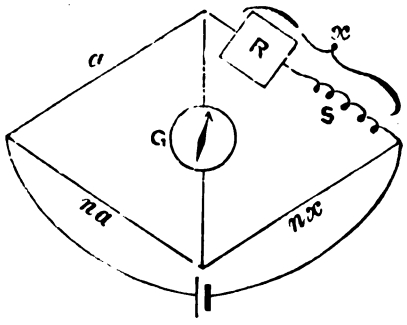
ON A METHOD OF MEASURING ELECTRICAL RESISTANCES WITH A CONSTANT CURRENT.*

It sometimes happens that the resistance of a body appears to depend upon the strength of the current which traverses it. This is the case, for example, with the carbon filament of an incandescent lamp, with selenium, with mixtures of sulphur and carbon, and with microphonic contacts. Without assuming that these are altogether true resistances, it is, nevertheless, sometimes convenient to treat them as such, and for purposes of comparison it is clearly necessary that currents of known or constant strength should be used in their measurement. When the Wheatstone bridge is employed in the usual manner, the current passing through the unknown resistance will, of course, depend upon the magnitude of this resistance, but by a simple modification of the common arrangement it is is easy to ensure having currents of uniform strength throughout a series of measurements. In the figure, x, nx, a, na are the four arms of a Wheatstone bridge, S is the unknown resistance, and R is a box of resistance coils which is inserted in the same arm. If E denote the electromotive force of the battery, B its internal resistance, and C_1 the current which passes through the arm containing S, then, when there is a balance,

$$C_1 = \frac{n}{n+1} \times \frac{E}{B + \frac{n(a+x)^2}{a+x+n(a+x)}}$$

$$= \frac{nE}{(n+1)B + n(a+x)}$$

From this expression we can find what value x must have in order that the current through the unknown resistance may be of any definite strength. Having determined this value, we insert resistance equal to n times its amount in the arm nx, and adjust the resistance of R until a balance is obtained. We then know that the resistance of R + S is equal to x, that the resistance required to be measured, S, is $x - R$, and that a current of the desired strength, C_1, is passing through it. A second unknown resistance may now be substituted and measured as before, simply by altering the resistance of R, with the certainty that when there is a balance the current is of the same strength as in the former



case. The resistance nx remains unchanged throughout. It is, of course, necessary so to choose the values of a, n and E, that x may be greater than the resistance to be measured.

Suppose, for example, that the electromotive force of one battery is 5 volts, its internal resistance 4·5 ohms, that $a = 10$ and $n = 100$, and that we desire a constant current of $\frac{1}{10}$ ampere. Then we shall have

$$\frac{1}{10} = \frac{500}{101 + 4{\cdot}5 + 100}(x + 10)$$

whence

$$x = 35{\cdot}455$$

$$= 35{\cdot}46 \text{ nearly.}$$

We therefore put a resistance of (35·46 × 100 =) 3546 ohms in the branch nx, and vary the resistance in the box R until the galvanometer indicates a balance. It is evident that the resistance of R and S together ($= x$) is then 35·46 ohms, and that a current of $\frac{1}{10}$ ampere is passing through them. In order to find the resistance of S alone it is simply necessary to subtract from 35·46 ohms the unplugged resistance in R.

The great advantage of this method over others that suggest themselves lies in the fact that since it is never necessary to close the circuit for more than a moment the E.M.F. and resistance of the battery remain sensibly constant during a long course of experiments.

* Abstract of a paper read at the meeting of the Physical Society, March 10th, 1883, by Shelford Bidwell, M.A.

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CORRESPONDENCE.

AYRTON AND PERRY'S ERG-METER.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The proof of Mr. Shoolbred's paper, which was put in my hands at the meeting, contained the theory of the Ayrton and Perry erg-meter, and I was not aware, until seeing the letter of your correspondent last week, that the theory had not been explained by Mr. Shoolbred. The fixed coil repels the moving coil, which is the pendulum bob, but the repulsive force in any position of the pendulum is only a very small fraction of the force due to gravity. The repulsion between the two coils for any position is proportional to the product of the currents flowing in them, and as through the fixed coil the main current flows, and the ends of the moving fine wire coil are attached to the supply and return cables of a house, and the current which circulates in the fine wire coil is proportional to the difference of potential between the supply and return cables, for any position of the coils, the repulsion between them is proportional to current multiplied by difference of potentials; that is, the electrical horse-power given to the house. Mr. Shoolbred proceeds to say:

"If c be the current passing into house and v the difference of potential of supply and return cable, then $c\,v$ is proportional to the electric horse-power given to the house.

"Now, the time of vibration of the pendulum is

$$t = \pi \sqrt{\frac{M}{g - k\,c\,v}}$$

if the magnetic force is a retarding one. M, g, v π are constants—so if that the time of clock, when no electricity is passing, be called T, then $\frac{T}{t} = \sqrt{\frac{g - k\,c\,v}{g}}$.

"Now, care is taken that the electro-magnetic forces are very small in comparison with gravitation forces acting on the pendulum bob; so that, to a degree of approximation which is sufficiently correct in practice, the above equation becomes $\frac{T}{t} = 1 - \frac{k}{2\,g}\,c\,v$. The rate of loss in the clock is, therefore, represented by $\frac{k}{2\,g}\,c\,v$. That is, it is proportional to $c\,v$, the electrical power. Hence, the total loss of the clock during any time represents the total electrical energy given to the house during that time."—Yours, &c.,

JOHN PERRY.

10, Penywern-road, South Kensington, S.W.

WANTED, A PORTABLE LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I would be thankful if you, or some kind correspondent, would describe an electric lamp to be used by musicians to read their copies while marching out at night.

I notice in this week's *Electrician*, March 10th, page 387, a paragraph upon induction coils, portable batteries, and electric lights, the title of a paper read by Mr. C. J. Clark, in which there is mention of a gentleman who showed an electric light burning in his scarf pin, being supplied from a small portable battery carried in the waistcoat pocket.

Would such a light answer my purpose? as, if so, a description of the different parts would oblige.—Yours, &c.

ONE IN THE DARK.

THE BEHAVIOUR OF CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you, or any of your readers, explain the following for me:—How does the current in an external circuit of homogenous character behave? I read in S. P. Thompson's "Electricity and Magnetism," p. 178:—"(A) The magnetic and chemical action of a current are proportional;" and in Clerk Maxwell, p. 292, Vol. I., "(B) The strength of a current as thus measured (*i.e.*, by voltmeter) is the same at every part of the circuit."

How is this reconciled with (C) C. Maxwell, p. 295, Vol. I., sec. 241 (9 v.)—"If by means," &c.? . . . .

Now, from these extracts, it appears that either the E.M.F. of the circuit varies each inch (C) or it does not (B).

Now, $C = \frac{E}{R}$ in any section or for the whole line. The current by (B) does the same work at any point. Resistance certainly does not decrease, ∴ E cannot diminish. In any similar sections the numerical values of $C = \frac{E}{R}$ must be equal.

No doubt some stupid misreading bothers me, but I cannot see it.

The Diagonal Slitting of Commutators.

What, again, is the virtue of the diagonal slitting of the commutator in a Siemens H armature machine? All other (multiple coil) machines are content with parallel bars.—Yours, &c.,

W. T. F.

March 14, 1883.

IMPROVING A DYNAMO MACHINE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We beg to enclose you a letter for publication from Messrs. W. Hope and Sons, Leith.—Yours, &c.,

J. E. JACKSON, Manager.

The Electric Carbon Storage and Apparatus Manufacturing Company of Scotland (Limited), Exchange-buildings, Leith, March 12, 1883.

[Copy.]

"Leith, March 12, 1883.

"This is to certify that, having placed in the hands of Dr. Paget Higgs, Electrician to the Electric Carbon Storage and Apparatus Manufacturing Company of Scotland (Limited), a dynamo machine capable of running as per maker's instructions 14 lamps of 15 candles each at a speed of 1,300 revolutions per minute, this machine has been made by most simple means to run constantly 15 lamps of 20 candles each at a speed of 950 revolutions, being an increase of 43 per cent. in lighting power, with a decrease of 27 per cent. speed.

"The machine had been supplied to us by one of the largest and most noted companies.

(Signed) William Hope and Sons."

THE RESISTANCE OF COPPER WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I shall be greatly indebted to you if you will kindly assist me respecting the following:—

In "Electric Illumination," by J. Dredge, page 328, I find the following:—

(No. 1.) "The resistance of a wire of pure copper, 1 mill. in diameter and 1 kilometre in length, is 20·57 ohms at 0° C."

Then follows a formula based on the above statement.

On page 15, *The Electrician*, Vol. 10, in the answer to question 5, there is the following statement:—

(No. 2.) "One foot of hard drawn Cu wire, 1 mill. diameter at 32° F., has R = 9·940 ohms."

As 0° C. = 32° F., and as 1 kilometre = 3,280·8ft., ∴ the *statement* from "Electric Illumination" may be re-stated as follows:—

(No. 1.) 3,280·8 feet of pure Cu wire, 1 mill. in diameter, at 32° F. has R = 20·57 ohms.

My difficulty is that I cannot make statement No. 1 agree with No. 2, nor anything near it. I was employed the other day a very considerable time in trying to work question No. 5 (as above referred to) from the data of the formula in "Electric Illumination," without success. I therefore beg to ask

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you to point out the discrepancy in the two statements, if any exists, with the correct formula.

Clark's Induction Coil and Battery.

Respecting Mr. C. J. Clark's small induction coil and portable battery mentioned on page 387 of *The Electrician*, March 10, I shall deem it a favour if you can assist me with answers to the following:—

1. Whether they are now manufactured for sale?
2. If they are, where can they be purchased, and what is the price?
3. The postal address of the above Mr. C. J. Clark.
4. Where could I see a full description of the construction of Clark's (C. J.) coil and battery?—Yours, &c.,

JAMES GRUNDY.

[You will find an answer to your question under "Answers to Correspondents."—ED. *E.*].

SAFE WORKING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. Forbe's letter in your last issue, I beg to give the method by which the figures for safe working currents in *The Electrician* supplement were arrived at.

The method employed is that of calculating the work done in heating a conductor by passing a current through it. Thus:

$C^2R \times 44{\cdot}24$ = number of foot lbs. per minute,

or $\dfrac{C^2R \times 44{\cdot}24}{772 \times 60}$ = number of units of heat per second.

Taking the unit of heat as the quantity of heat required to raise 1lb. of water 1°F., and taking the specific heat of copper as ·0949, one unit of heat will raise 5·854lbs. of copper 1°C. Hence:—

$$\text{Rise per second in degrees C.} = \frac{C^2 R \times 44{\cdot}24 \times 5{\cdot}854}{772 \times 60 \times W}$$

$$= \frac{C^2 R}{W} \times {\cdot}00559 \quad . \quad . \quad (1),$$

W being the weight of the conductor, the resistance of which is R.

Next it is *assumed* from practice that an ordinarily insulated cable, composed of 19 strands of No. 19 B.W.G. copper wire, will *safely* carry 50 amperes. Then

$$\text{Rise per second} = \frac{(50)^2 \times {\cdot}098}{30{\cdot}2} \times {\cdot}00559 = {\cdot}045°\text{C.}$$

Substituting in (1) and multiplying out

$$C^2 = 8\frac{W\ (\text{in lbs.})}{R\ (\text{in ohms})} \text{ approximately.}$$

This formula was calculated for private use, and has been very serviceable, although it probably gives results very considerably on the safe side, and, of course, is only applicable to comparatively short lengths of conductors, in which the question of resistance and economical working does not enter. I hope this subject may now be thoroughly ventilated by your correspondents.—Yours, &c., W. B.

7, Bute-street, South Kensington.

AN ARC LAMP TO BURN AT ANY ANGLE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to inform you that the communication from me in reference to the above does not refer to that devised by Mr. Oliver H. Kenny, and that its working principles are in quite a different direction. Mr. Kenny's lamp contains at least ten electro-magnets, and a great deal of complication, while the lamp invented by me contains one electro-magnet and a solenoid. This works or operates a very simple clutch, in which the carbons are made to approach or recede as circumstances may require. The lamp may be turned upside down, or put at *any angle*, without requiring the least adjustment, and will maintain an arc proportional to the E.M.F. or current passing. It will regulate or feed in the midst of dust without a flicker or any perceptible movement in the light whatever. If there is any doubt attached to this I will exhibit the lamp to those interested, and challenge Mr. Kenny to do the same.—Yours, &c., R. BOWMAN, Patentee.

Cadby's Steam Works, Leather-lane, E.C.

NEW TELEPHONE TRANSMITTERS.*

BY J. MUNRO, ASSOCIATE.

It was during the well-known telephone trial of last summer† that I began to think of getting out a new transmitter. In order to be a novel instrument, and avoid clashing with the Edison and other patents, it was necessary that a new transmitter should fulfil certain conditions; and my connection with the trial showed me what these conditions were.

The broad claim of the Edison 1877 patent is for the combination of a tympan, or drum, with a "tension," or, as I would rather call it, a "current" regulator of semi-conducting material. The particular material used by Edison was lampblack, a form of carbon; but the claim has been held in courts of law to embrace all kinds of carbon, and might even be extended to all so-called "semi-conductors."

Since the memorable discovery of the microphone by Professor D. E. Hughes, a great many patents have been taken out in England and abroad for carbon transmitters of one form or another; but the supremacy of the Edison patent has in general paralysed these efforts, and rendered the improvement worthless. It is even doubtful if the substitution of protosulphide of copper for carbon by Mr. Moseley, in a recent transmitter, will be clear of the Edison claim, since that salt is a semi-conductor.

I determined, therefore, to keep clear of semi-conductors altogether, and, if possible, too, of tympans. The transmitters which I have the honour of bringing before you to-night are made of metal—that is to say, the current-regulator is formed of conductors, so arranged as to render a tympan unnecessary.

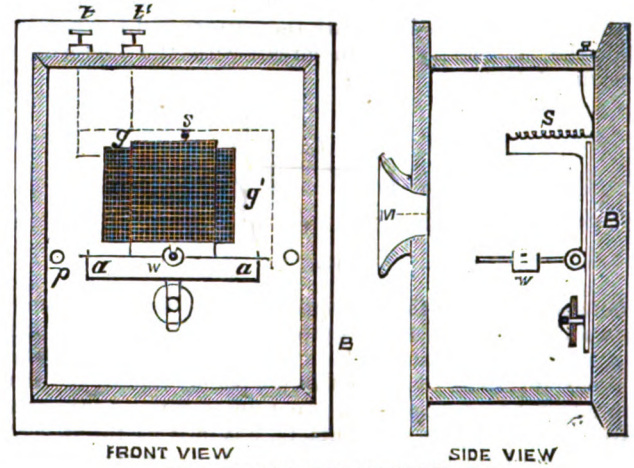

FIG. 1.

Some experiments I had occasion to make in the course of the telephone trial showed me the promise which lay in metals as a material for transmitters—a promise first discovered by Professor Hughes in his microphone researches, but neglected by electricians because of the apparent advantages of carbon. I did not believe that the action of the microphone was due to diminution of resistance at the points of contact, by pressure causing greater or less area of surface contact, according to the current theory at that time. It seemed to me that the film of air between the contact points played an important part in its action, and that the electrodes of a microphone might be of any conducting substance—for example, metals—without destroying its peculiar power of transmitting sounds. I thought, in short, that the current passing through the air between the loose contacts made the sensitive part of the microphone, and that sound-waves traversing this film of air would transmit themselves whether the electrodes were conducting or semi-conducting, carbon or metal.

What kind of metal to use and what particular form to give it, in order to get good articulation and durability of

* Paper read before the Society of Telegraph Engineers and of Electricians, on Thursday, March 7, 1883.

† The United Telephone Company *v.* Harrison Cox-Walker.

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action, were questions which only experiment could answer. In working out my ideas on the subject, I had a very able colleague in Mr. Benjamin Warwick, whose zeal in these experiments has been unflagging.

Mr. Munro here described his experiments in detail. Continuing he said:—

The use of wires in these experiments led me to the idea of employing two light wire gratings resting on each other under slight pressure, and forming a metal microphone with multiple points. It seemed that the light open structure would allow the sound-waves to agitate the contacts without the intervention of a tympan, and something after the manner of an Æolian harp.

Fig 1 is a transmitter made on this plan. It consists externally of a wooden box, B, having a mouthpiece, M, closed by a piece of match-wood. Inside the box is the microphone, or "current-regulator," which consists of a piece of ordinary iron-wire gauze, *g*, lightly pressed against another piece, *g'*. The back piece of gauze *g'* is fixed to the back of the case, but the front piece *g* is carried by a loose axle, *a a*, supported in bearings at each end. From the axle projects an arm carrying a movable counterweight, W, and the downward pull of this weight tending to lift the front gauze off the back is balanced by the force of an adjustable spring, S. The pressure on the microphonic contacts is regulated by this means. The stops *p p* serve to limit the sidelong play of the axle carrying the movable gauze when it is found convenient to shift the position of the latter in adjusting the instrument.

The current enters and leaves the regulator by the terminals *t t'*. A small induction coil (not shown) is usually inserted between the transmitter and the line, the "primary" of the coil being in circuit with the battery and the regulator, while the "secondary" is in circuit with the line wire and receiving telephone.

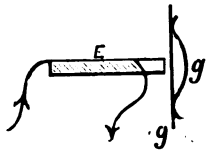

Fig. 2.

On speaking into the mouthpiece in the usual manner, the air-waves set up by the voice pass through the two gauzes, and agitate the contacts between them, thereby modifying the current so as to make the telephone repeat the words. The match-board diaphragm is not an essential, as the sound-waves act directly on the contacts, but it is useful in screening the regulator from the rudeness of the breath, and fixing the distance at which the speaker should keep. A grating across the mouthpiece answers almost as well. In another form which we have constructed, the sound-waves are reflected upon the regulator by an acoustic mirror; and in a third form the regulator is carried by a sounding-board. The sonorous properties of the case may also be improved by the use of sounding-posts.

In fact, there are many details of construction which I need not take up your time in describing. The pressure between the electrodes can be regulated by means of magnetism, as well as gravity or the tension of a spring, especially when, as in this case, the metal employed is iron. The pole of a permanent magnet presented to the gauzes will hold them together with a force depending on the nearness of the pole. When an electro-magnet, E, is used as in Fig. 2, the current itself may traverse the coil of the magnet, and hold the gauze *g* against *g'* with a force which will be stronger when the current is stronger, and thus enhance the pressure of the sound-waves, so as to give a more decisive action. For since increased pressure of the sound gives increased current through the regulator and electro-magnet, the latter will react on the gauze so as to intensify the pressure and accentuate the voice. The electro-magnet E may be the core of the induction coil used with the transmitter.

In his original paper on the microphone, Professor Hughes states that the microphonic contact between two pieces of metal should be clean, but we find that the gauze may be either clean or tarnished, provided the rust upon it is not so thick as to make the surfaces adhere to each other.

Two pieces of gauze are not essential to the transmission of sounds, as one piece resting on a flat metal plate, either plain or corrugated, will answer; so also will two thin metal plates with roughened surfaces. But gauze is the most convenient and successful material we have yet tried. Its sensitiveness to tremors is remarkable, and it possesses an elasticity, when properly adjusted, which a continuous diaphragm does not seem to have. The numerous points of contact which it offers to the current, its low internal resistance, its lightness, portability, and cheapness, are all in its favour as a telephone transmitter.

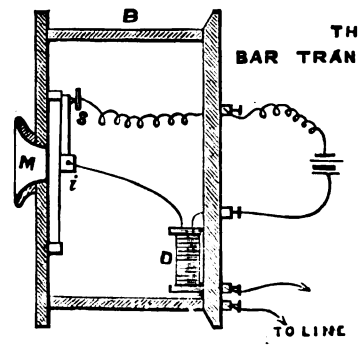

Fig. 3.

Fig. 4.

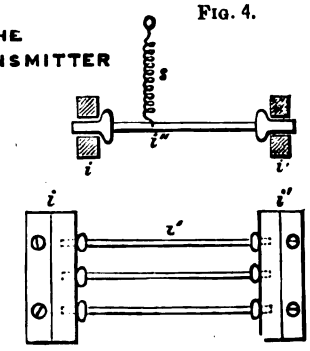

Fig. 5.

Another type of metal transmitters is shown in Figs. 3, 4, and 5. The B is the case, as before, with a match-board screen, M, and behind it a flat sounding-board carrying a metal microphone, *i*, with its adjusting spring, S. An induction coil, D, having its "primary" in circuit with the microphone and battery, and its secondary in circuit with the line, is also contained in the case. The microphone is formed of a light metal bar, *i''*, resting by its ends in holes drilled in two metal blocks, *i i'*, Figs. 4 and 5. An adjusting screw, *s*, regulates the pressure between the bar and its bearings. The metal found most suitable is common cast-iron, which may either be clean or slightly tarnished.

On speaking into the mouthpiece the vibration of the sounding-board causes the iron contacts to transmit the voice. A little clock oil applied to the bearings serves to remove the "boiling" or "buzzing" sound which is apt to spoil the action of the transmitter. Clock oil is chosen because it does not freeze in winter, and because it will preserve the iron from further rusting; but other liquids are found to answer the same purpose.

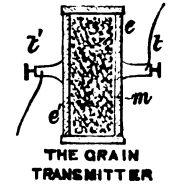

Fig. 6

The sound given by the cast-iron is loud, clear, and buoyant, but the proper adjustment of this form of transmitter is not so easy and abiding as that of the gauze type above described.

A third type of transmitter is shown in Fig. 6. In this the current-regulator consists of metal granules, *m*, enclosed in a box between two metal plate electrodes, *e e'*, connected to the terminals, *t t'*. The back of the box may either be of wood and the front of wire gauze, or both may be of sonorous wood. Iron or brass filings and turnings serve as metal grains, especially those with a good deal of inherent resilience, or spring; but a pile of small ¼in. screw nails, or a grit of "spongy iron," give better results. Spongy iron, having a rough surface, approximates to carbon in its action. To reduce the boiling or buzzing sound caused by the continual trembling of the particles, we sometimes immerse them in a

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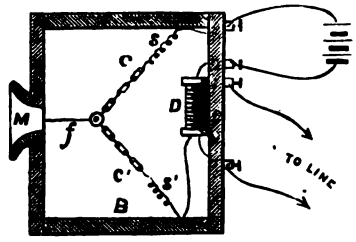
liquid, such as alcohol or thin oil. The liquid must not be viscous, else the vibration of the particles is clogged, and articulation ceases. Castor oil, for example, or glycerine, reduces the transmitter to silence. The removal of the buzzing in this way always appears to be at the expense of loudness in the articulate sounds. The steadying effect of the liquid on the delicate microphonic contacts is not its only influence, for, besides acting as a fine vibrator, it preserves the contacts from fouling overmuch, or from sticking together in the way investigated by Mr. Stroh.*

I may add that I have found some kinds of writing ink transmit speech when held in a box like that described.

A fourth type of transmitter is that shown in Fig. 7, where B is a box, as before, with a mouthpiece, M, and an induction coil, D. The mouthpiece in this case is closed by a tympan connected at its centre to a metal chain, or strip of chain mail, *c c'*, which is strained by the springs, *s s'*, and the tie *f*. This chain is the current regulator, and is traversed by the current. Between every two links there is a microphonic joint. The vibration of the tympan, on speaking in front of it, tightens or slackens the chain, thereby operating the current regulator and transmitting the sounds. The pressure between the links, which, by preference, are of iron, is regulated by adjusting screws.

Apart from their value as practical instruments, whatever that may turn out to be, these transmitters are instructive in a scientific sense. They show that metal contacts are quite capable of transmitting speech, and that, contrary to the doctrines of more than one eminent scientist, carbon has no monopoly of articulation. There has been a tendency of late to minimise the great discovery of Professor Hughes, and regard the microphone as a mere variety of the Edison carbon transmitter. Sir William Thomson himself appears



THE CHAIN TRANSMITTER.
FIG. 7.

to share this view, for he has stated, under examination, that he does not think the discovery of the microphone was any important advance beyond the carbon telephone. The part played by metals in the microphone, a part undreamt of until Professor Hughes's discovery, has been hitherto ignored. In point of fact, however, it is more than half of Professor Hughes's discovery, as these metal transmitters demonstrate. For the carbon microphone is now shown to be only *one* illustration of Professor Hughes's wide discovery, that a delicate contact between any two *conductors* has the property of transmitting sounds. The Reis original transmitter, with a delicate platinum joint, is seen to have been another illustration of the same phenomenon. Professor Silvanus Thompson has recently presented proof that Reis did send articulate words by his transmitter; and I believe there is no doubt he did. I have myself heard by telephone, and understood, single words spoken direct to the platinum contact of a Reis transmitter. Reis, then, employed a platinum microphone, without knowing it, as early as 1861; and Edison used a carbon microphone, without knowing it, in 1877. The discovery of Professor Hughes, in 1878, threw a flood of light on both inventions.

The action of tarnish was probably not observed before the experiments of Mr. Warwick and myself, as both Professor Hughes and Herr Reis were careful to have clean contacts. Even Mr. Edison, in the long catalogue of materials claimed for his transmitter, and numbering nearly all known substances, as well as several which remain to be discovered (either in this world or the next), does not, I believe, mention rust.

Mr. Munro here invited the attention of the meeting to some working specimens of the above-described transmitters. Proceeding, he said:—

My first intention was only to bring the metal microphone transmitters to your notice this evening; but perhaps something might be said in addition to the current theories of the action of the microphone from the point of view of these transmitters.

The original theory of Edison, that it is due to a reduction of the internal resistance of carbon by pressure, is probably not maintained any longer in face of the numerous experiments showing that there is exceedingly little reduction, if any. Then there is a theory—supported, I believe, by Sir William Thomson—that the action is due to an increase or diminution in the area of surface-contact produced by increase or diminution of pressure; but how the area of contact is to vary in simple ratio to the surface-pressure is a puzzle in this theory which is difficult to see through. A third theory, due, I believe, to Mr. Preece, is that the microphone acts by heating at the points of contact when the current passes. I have not seen this theory developed anywhere, and may not understand how the heating is supposed to act; but if it acts by altering the resistance of the points, then in the case of carbon we have a dimunition of resistance, and in the case of metals, more especially iron, a rise. Yet, as we have seen, metal points, as well as carbon ones, act as transmitters. The theory, then, does not seem to fit both classes of instruments. Again, it does not seem probable that the variations of temperature can be so quick and sudden as the transmission of sonorous currents requires. The logograph curve shows that a jerky action is necessary, and the heating and cooling of a body must be more or less gradual. Another reading of the theory may be that the heated points are of a spongy nature, and more sensitive to pressure; but here again it is difficult to see how the effect can be in simple ratio to the pressure. A fourth theory, supported by Professor Hughes and Professor Blyth, and probably first intimated by Mr. F. H. Varley,* attributes the action of the microphone to a small arc formed between the points, and this appears to me a likelier hypothesis. But I would propose a modification of it, and, instead of an "arc," in the ordinary sense, consider the cause a "silent" discharge through the film or stratum of air or liquid between the points, after the manner of lightning guard. With a strong current one can see sparks passing between the points of the microphone, but this momentary arc is due to excess rather than to normal action. The normal action is evidently produced by a silent discharge going on between numerous tiny projections on the carbon points, which in this respect resemble the corrugations or spines in two well-known forms of plate lightning arrestors used in telegraphy. We have to figure to ourselves the microphone points covered with irregular projections which touch each other, but are bathed in the surrounding air and ether. These projections, like the points of a lightning arrestor, are constantly discharging little jets of current from one to the other across the air between. But the action of the sound-waves is to move them to and from each other, thereby increasing and lessening the width of the air stratum, and varying the strength of the discharge. When this vibration is clogged by a viscous liquid, the sounds are muffled and indistinct.

The "boiling" or "buzzing" of a metal transmitter not properly adjusted reveals this "silent" discharge from a multitude of points. The ear hears in the telephone a peculiar soft noise, quite indescribable, but apparently made up of a million feeble ticks, the feeblest the ear can appreciate. Each tick seems to be caused by an infinitesimal discharge between two little points, and the agitation of these points causing the discharge is the perpetual tremor going on in all substances, especially elastic metals. A slight pressure applied to the microphone quiets this discharge and leaves the sonorous vibrations to act by themselves in disturbing the flow of electricity through the air. It silences the buzzing of the crowd, as I may call it, and allows the voice of the speaker to be heard.

With two pieces of iron wire gauze, one delicately resting on the other, I have sometimes obtained this breathing

* See *Journal of the Society of Telegraph Engineers*, Vol. IX., p. 182.

* See *Telegraph Journal*, Vol. VI., p. 404.

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sound very perfectly without the application of heat. In loudness it resembled the rushing of a strong wind. The slightest oscillation of the upper gauze until it came to rest was rendered in the telephone. Even the periodic tremors of my hand, in contact with the table, were distinctly given, and broke up the blast like the puffing of an engine.

The application of heat, by the spirit flame, to two pieces of wire gauze in contact, increases the microphonic action between them in a similar manner, as can be shown by placing the spirit lamp below such a contact. When the flame is applied to the metal so as to heat the contact, the tapping of my hand, as heard in the telephone, becomes louder, and gradually dies off when the flame is removed. Hot metals and flame are known to discharge electricity better than cold metals, and hence, in all probability, the slow discharge of the microphone is accelerated by this means.

Heating the contacts can of course be applied to the metal transmitters which I have shown, especially the gauze forms; but I have not yet had time to properly try this plan. The superiority of iron in these transmitters may be due to the ease with which it discharges, as compared with the other metals tried; but heating facilitates the discharge of other metals besides iron. A transmitter of platinum wire gauze, which would not oxidise in the flame, as does copper, for example, might therefore be constructed; the spirit lamp being fed from a reservoir attached to the case and lighted at will by an electric current sent through a platinum wire on touching a press-button, or in the act of unhooking the telephone receivers from the case in order to converse.

When the microphonic contact is formed by two different metals, the application of heat generates its own current by thermo-electric action. I have here a contact formed of iron and German silver, and on applying the spirit lamp, and tapping, we hear the taps in the telephone. In Dr. Mathiessen's scale of thermo-electric effects, bismuth ranks 25, German silver 5·2, and iron 5. I have not yet made a thermo-electric microphoone to speak well, partly because iron and German silver do not give a very loud effect, and bismuth is difficult to get in a workable shape; but I hope soon to try the effect of bismuth gauze resting upon iron gauze, and artificially heated.

The recent experiments of Mr. Shelford Bidwell, communicated to the Royal Society on January 18th, 1883, appear to me to bear out the theory that the microphone acts mainly through the air discharge between the points. Thus he finds that the resistance of the contacts varies greatly with the strength of current when the pressure is small, and very slightly when it is great—that is to say, when the film of air is squeezed out. On reducing the pressure (with carbon at least), the resistance of the contact increases. Again, the resistance of the contact diminishes with increased current, an effect also noticed in the voltaic arc. Further, Mr. Bidwell finds that "when the strength of current exceeds a certain limit the resistance is greatly and permanently increased; the greater the pressure the higher will be such limit." This unexpected effect is difficult to explain on any theory but that of the "air discharge." May it not be due to a counter-electromotive force generated by the discharge? M. Edlund finds that a resistance is set up at the electrodes by a discharge in rarefied air, and the effect observed by Mr. Bidwell may be a similar one.

In his paper to the Royal Society Mr. Bidwell gives reasons for the superiority of carbon over metals in the microphone.

He says:—"The mere fact that a current causes delicately-adjusted metal contacts to adhere to each other is sufficient to account for the superior efficiency of carbon. A metal microphone might indeed be used to transmit the pitch of a sound, provided that its vibrations were sufficiently powerful to cause actual separation of the points of contact. The fundamental tone might in this way be conveyed, but it is clear that the minute superimposed vibrations due to the upper partials, upon which depends the distinctive character of a particular sound, would be very imperfectly represented, if not entirely lost."

I can only say that I have not found the adhesion of contacts in these metal transmitters troublesome, although iron, according to Mr. Stroh's* experiments, has a very high adhesive power. If the battery power is not too great, and the pressure on the contact is not excessive, there will be no sticking of the points.

On the question whether a metal microphone can convey the human voice, I will leave the transmitters to speak for themselves; but I may say that shrill or high-pitched voices, like those of women and children, seem to come out best. This appears to be due to the fact that the discharging distance in the case of metals is very small, and the contacts should not swing too far apart. In a female voice there are twice the number of vibrations per second as compared with the male voice, and the metal points must vibrate in very close proximity when a woman speaks to the instrument. The same peculiarity is, I believe, observed with carbon microphones, and any advantage carbon may have in this respect will lie, I think, in the greater width of arc or discharging distance which it can sustain by reason of the cloud of carbon particles carried by the current between the contacts. I may add that the conducting fumes in the heated metal microphones evidently enable these to sustain a longer arc than if they were cool.

So marked is this difference between male and female voices, that on some of the forms of transmitter I have shown it is possible to hear a female voice with singular clearness when a male voice cannot be understood without altering the adjustment. But, of course, a transmitter purely for female voices would not be very practicable, at least in our day. It would, indeed, be possible to have two transmitters, one for male and the other for female voices, connected at each end of the telephone line, so that a man might speak into one, and a woman into the other. But there would still remain the insurmountable difficulty of providing for the anomalous case of a youth whose voice was in the act of breaking. It would be too much, gentlemen, to ask him to fly from one instrument to another when his voice took a turn in one direction or the other, even if he knew when the anomaly was coming on. Fortunately, however, the gauze transmitter is available for all kinds of voices when properly adjusted; and the same may also be said for the other forms. For male voices more pressure is required on the contacts; but when once an instrument is adjusted for a middle voice, it will convey others of a higher and lower pitch. Thus a transmitter set to an alto voice will also serve for bass and treble speakers.

MR. STROH ON THE ACTION OF THE MICROPHONE.

An experiment, which may help to throw light upon the action of the microphone, was described by Mr. Stroh during a discussion on the theory of the microphone which followed the reading of Mr. Munro's paper at the Society of Telegraph Engineers and Electricians on the 8th inst.

Fig. 1. represents a very small and delicate form of Professor Hughes's so-called hammer and anvil microphone.

On a thin board, A, is fixed a little block, B, which serves to hold four brass uprights, C C′ and D D′.

A light spindle E, provided with a pivot or knife-edge at each end, rests on the uprights C and C′. Attached to the spindle E on one side is an exceedingly light concave reflector, F, while on the other side, and in good electrical contact with this spindle, is a thin rod of carbon, G. The latter rests at right angles on another rod of carbon, H, which is firmly fixed in the two brass uprights D and D′.

Terminals I and I′ communicate each with a pair of the brass uprights. A little spiral spring, the tension of which can be regulated by a small thumbscrew, serves to keep the two carbons in microphonic contact.

A loud ticking watch or other source of sound is placed on the board A.

The general arrangement of the experiment is shown in Fig. 2. M is the microphone just described. A lime-light, L,

* Some further investigation by Mr. Stroh on the subject of the action of the microphone will be found described below.

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is placed behind a little screen with a small round hole in it, across which is stretched a fine wire, so that the image of the latter is thrown by the reflector of the microphone on a wall or screen at S, where a graduated scale may be fixed, and where by means of the image of the fine wire any deflection can be easily read.

A downward movement of the reflected spot of light on the screen S indicates a separation of the carbons at the point of contact, while an upward movement would be due to an approach of the carbons towards each other.

A telephone, T, a make-and-break key, K, a battery, B, and the microphone M are joined in circuit. The adjustment of the latter is now made, so that the ticking of the watch is heard as loud as possible in the telephone T, while the observer has one hand on the key K, and is also watching the spot of light at S.

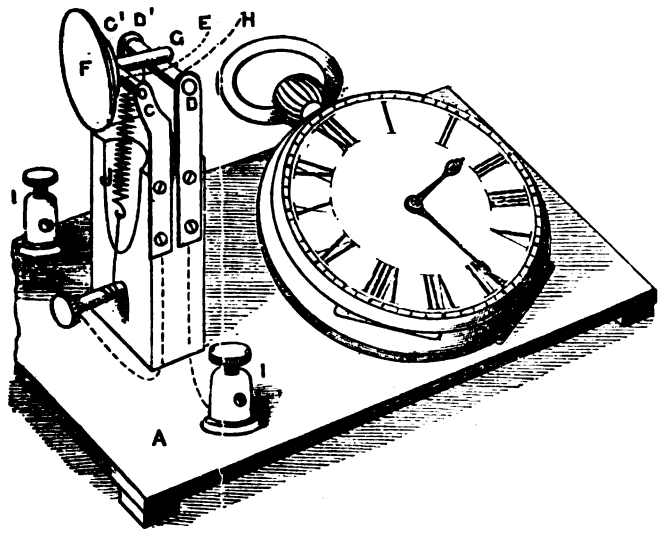

Fig. 1.

At the instant when the current is broken at K the spot of light moves upwards, not sluggishly, but suddenly and sharply, the sound in the telephone of course ceasing at the same moment.

On making contact again the spot of light, quite as suddenly, returns to its former position, while the ticking is heard again.

The distance through which the spot of light moves is very small, but the action is so decided and unfailing that there is no difficulty in observing it.

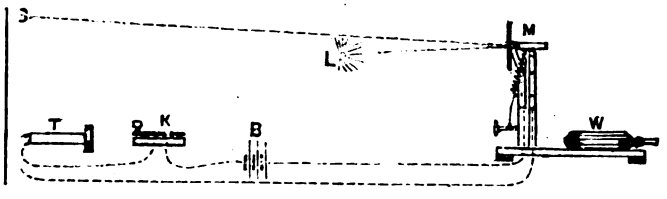

Fig. 2.

It happens sometimes that microphones are uncertain in their action, and will suddenly fail to work, and in observing the spot of light during some such failures it was found that it jumped upwards at the moment when the telephone became silent, and returned as soon as the microphone was brought into action again by a tap on the table.

It was *only* during the clear working of the telephone that the spot of light remained steadily deflected downwards, which seems to indicate that during the time when the carbons are really in what is called microphonic contact they are not in contact at all, or at all events that there is a repellant action at the points of contact.

With a single element of a small bichromate battery in the circuit the deflection was hardly perceptible; but with three elements the spot of light moved through one millimetre between making and breaking.

When a greater number of elements was used the deflection was also greater, but there was much hissing, and the spot of light was not steady.

With three elements the experiment succeeded best; with this number the ticking of the watch could be heard loudly and clearly without any hissing.

In order to arrive at an estimate of the distance which appeared to exist between the two carbons at the point of contact during their action as a microphone, it may be mentioned that the distance between the screen S and the reflector was six metres, and that between the fulcrum and point of contact of the microphone six millimetres, so that the former distance was 1,000 times greater than the length of lever in the microphone. This figure has to be doubled on account of a reflected beam of light moving through double the angle of the reflector itself.

The total deflection on the screen S being one millimetre, the distance to which the upper carbon was repelled during microphonic action under the circumstances described was therefore $\frac{1}{2000}$th part of a millimetre.

ELECTRIC LIGHTING AND LOCOMOTION.*

In my last lecture, I explained why small current combined with great electric pressure or high potential must necessarily be used for economy in electric transmission of power, and why, therefore, the series working of lamps and motors was better than the parallel system. I went pretty fully into the consideration of what was necessary to obtain safety, and we found experimentally that two conditions were essential: the first, that both the going and the return wires should be well insulated from one another as well as from the earth; the second, that the current should be absolutely constant in its strength, and not merely have the mean constancy obtainable with many of the so-called constant current dynamos.

The very important problem of supplying constant electric pressure to the mains, however many lamps or motors were being fed by them in parallel, was next considered, as well as the problem of supplying constant current to motors or lamps in series, however many lamps or motors were being worked in one circuit.

We ended by considering the great importance of driving quick moving tools like drills, fans, circular saws, &c., *directly* with electro-motors without intermediate gearing, because with such arrangement we saved first the loss of power that occurs in the shafting of a factory; secondly, the loss of power at the intermediate gearing employed to make the drill, or other quick moving tool, revolve much more rapidly than the shaft, and, lastly, we secured the great convenience of being able to bring the machine-driven tool to the work, instead of, as at present, the work to the tool. And there is one case where the driving of fans by electro-motors appears to me to be at the present moment of vital importance to us as citizens of London, I might almost say of national importance to us as Englishmen. For years past we have gone on breathing the foul air in the underground railway. Much grumbling has been the result, but hitherto no ventilation, and at the present moment we are contemplating, as a sort of final resource, the possibility of unsightly openings being made in the roadway of the Embankment to let out the obnoxious gases. Now why, I ask, do we not put fans at suitable intervals along the tunnel attached to quite small pipes for extracting the bad air? The fans could not, of course, be driven by steam-engines (there are steam engines enough in the tunnel already), nor could they easily be driven by shafting or belting, but an electro-motor attached *directly* to each fan would furnish the driving power without introducing any inconvenience whatever. No gearing would be necessary, a single insulated going and return wire would convey from motor to motor the electric power produced by a large dynamo outside the tunnel, and a steam engine might puff away in some back yard, out of everybody's way, and give us perfect ventilation on the underground railway.

And when on the subject of electro-motors, I explained that Professor Perry and myself had been led to construct electro-motors on a different principle from that usually adopted. In a dynamo machine there are two electro-magnets, and the machine acts as a producer of electricity because the work that is necessary to be done to move one of the magnets relatively to the other to overcome their attractions and repulsions is turned into

* Lecture II., delivered by Professor Ayrton, F.R.S., at the London Institution, March 15, 1883.

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electric energy. In practice one of these electro-magnets is usually kept at rest, while the other is in motion. In one of them the current always flows in the same direction, while in the latter it is constantly being reversed in direction. The former is called the "field" or inducing magnet, while the latter is the "armature." Now, it can be shown that in every dynamo-machine the magnetism produced by the current flowing round the armature must necessarily weaken the magnetism produced by the current flowing round the field-magnets, and hence must necessarily diminish the power of the dynamo.

Hence the best dynamos have been so designed that while the exciting electro-magnets form a very strong magnet the armature only produces a very weak one. This result has been arrived at partly by making the armature of a dynamo small, compared with the field electro-magnets, and partly by giving it a squat form; and because the field-magnet is large, it is, as a rule, kept stationary, while the armature revolves inside its poles.

I went on to explain to you that Professor Perry and myself had concluded from certain theoretical and practical considerations, that in an electro-motor, on the contrary, the strengths of the two magnetic fields produced respectively by the field-magnet and by the armature should be equal, since the one, so far from weakening the other, can be made to strengthen the other, and since the armature from its shape is necessarily rather a weak magnet, whereas the field, or exciting magnet, from its shape is a strong one, that we had reversed the usual condition of things, and made the armature large and the field-magnet small, and that from this we had been led to make the armature stationary and surrounding the field-magnet, instead of, as is usual, the field-magnet surrounding the armature.

Our small field-magnet, then, carries the brushes and revolves inside the stationary armature, the coils of which are joined to the stationary commutator, which, unlike ordinary commutators, we make flat to save both space and expense.

Wherever the brushes happen to be at any particular moment, there two opposite magnetic poles are produced on the armature. As the brushes run round and round so do these poles, and the brushes, which, be it remembered, are carried by the field magnet, are so set that the magnetic poles in the armature are always a little way in front of those in the field-magnet. The latter, therefore, are perpetually running after the former, but never catching them.

The law connecting the power of electro-motors with their size I dwelt on, and I explained that if the length, breadth and height of a motor be doubled, so that its weight and cost becomes eight times as great as before, its power is about 20 times as great as before, and its efficiency or the ratio of useful power given out to electric power put in is also much increased.

I ended my lecture by referring, but from want of time only very briefly, to the governing of motors. An ordinary ungoverned motor goes very much faster when running empty than when there is a load on, but in practice it would never do for a piece of wood or iron in a lathe to rush round when the chisel was taken off, since not only would there be a great waste of power, but on next applying the chisel it would be probably broken by the wood or iron when rotating with such an excessive velocity. Not only, then, must we arrange in the way I described, that the supply of electric power is proportional to the demand, but also that the motors consume this power in proportion to the work they have to do; in other words, the electro-motor must be governed so as always to run at the same speed, whatever amount of work it may happen to be doing. I referred to the oldest form of governor for motors, which I have called the "spasmodic governor,"* and which I will now show in action. [Experiment shown and full explanation given.] The great objection to it is that it either supplies full power when the motor is running too slowly, or no power when it is running too quickly, and, therefore, cannot produce a constant speed. Our "periodic governor," which never supplies full power or no power, but always an amount of power exactly in proportion to the demand, I very briefly referred to, and which I will now describe to you more in detail [Ayrton and Perry's "periodic governor" shown in action and fully explained]; and, lastly, I referred to the most advanced system of governing motors, which we had arrived at by winding the motor with two distinct circuits in such a way that the current passing through one of them magnetises the iron, causes the machine to act as a motor, and, consequently, is itself resisted, whereas the current passing through the other circuit tends to demagnetise the iron and stop the motion, and, consequently, is itself helped on; in fact, we have combined a motor and a dynamo in one machine, and so have dispensed altogether with anything of the nature of a mechanical governor. In the spasmodic, as well as in our periodic governor; the regulating action is produced by the supply of power being cut off when the motor is beginning to go too fast, but in our combined motor it is usefully employed to reproduce electric energy, which is added to the supply in the main circuit. In the one case, when less work has to be done by the motor, less electric power is given it, while with our combined motor the supply always remains the same, but when much work has to be done by the motor, nearly all the electric supply is turned into useful mechanical work; whereas, on the other hand, when little mechanical has to be done, a portion of the supply, after being turned into mechanical work, is re-converted into electric energy, and added to the supply going to other motors. The difference in principle is of this nature—the periodic governor corresponds with a man who, when he has not much work to do, does not eat much, lives economically; in fact, whereas our combined motor corresponds with a man who always eats the same amount every day, but when he has little work to do on his own account, immediately goes and helps somebody else who is hard pressed with work. [Experiments were then shown with the combined motor, and it was proved that the change of load which diminished the speed of the ungoverned motor from 1,560 revolutions per minute to 508, only reduced the speed in one of Ayrton and Perry's governed motors from 1,250 to 1,184 revolutions per minute.]

But we find that it is not even necessary to wind the motor with two distinct circuits in order to obtain a certain amount of governing, and this arises from the fact that our machine will act as a motor without any winding at all on the revolving field-magnets. Here is an example of such an unwound motor. I pass a current through it, and it at once commences to revolve, and, as you see, revolves rapidly. [Experiment shown.] This arises from the fact that the magnetism in the stationary armature induces magnetism in the iron of the field-magnets, and the brushes are so placed that the magnetic poles in the armature are always just in front of those in the iron, which latter are always running round and round after those in the former, but never catch them up.

In some of the early electro-motors pieces of soft iron moved in the neighbourhood of stationary electro-magnets, but in that case the continuous motion of the iron was maintained in a totally different way from that employed in our unwound motors, because in those older motors a piece of iron was pulled towards a stationary electro-magnet, opposite which it would have stopped, but that just as it was approaching the end of the electro-magnet the current was stopped and the iron went on by its own momentum; the pulls were therefore intermittent and not continuous, as in the case of our unwound motor.

(TO BE CONTINUED).

* See *The Electrician* for March 10.

ELECTRICITY ON TRAMWAYS.

The success which has attended the electrical tramways at Berlin, Brussels, Dusseldorf, &c., worked on the Siemens plan, by a stationary generator and a movable motor, has directed the attention of tramway officials to the use of electricity. It is well known that horse-power is expensive, not to speak of its cruelty, and neither steam nor compressed air have as yet made good their claims to be used in this application. The experiments of Planté, Faure, Sellon, Volckmar, and others in the direction of storage have culminated in an attempt to use electricity in this way to tramway work. A series of successful experiments have been carried out on the Acton tram line, but a similar experiment which the public were invited to witness at Kew was not so successful. The principal reason arose, we understand, from the fact that there is a difference of ⅛in. in the gauges of these lines, and the axle of a car made to run on one line is not quite the same as an axle of a car made to run on another line. It is expected that in a few days a car will be running daily and continuously, and we shall then take the opportunity of illustrating the car, and describing the general and special arrangements. Meanwhile, it will not be out of place to give the views expressed at the luncheon on Saturday last at the Star and Garter Hotel, Kew Bridge. A large number of gentlemen interested in the work were present, the chairman, Sir D. Cooper, of the Electrical Power and Storage Company (the host of the day), presiding.

At the request of the chairman, General HUTCHINSON gave his experience at the earlier trials on the Acton Road. He stated that the car ran satisfactorily at the rate of about six miles an hour. The speed was thought to be good, as the car was carrying about five tons weight. It might be necessary to alter one or two details after the morning's experience, but it was not expected that the Board of Trade would make any difficulty in licensing the running of these cars.

Sir F. BRAMWELL proposed "The Success of Electricity,"

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coupling the name of Dr. Siemens with the toast. Sir F. Bramwell pointed out that the applications of electricity were rapidly extending. It enabled us to talk and write at a distance. We were even able to grow vegetables by its use. Electricity had certainly developed wonderfully during the past few years. He knew of nothing that had made such great progress.

Dr. SIEMENS remarked that he had, probably, been connected with the applications of electricity longer than any other gentleman in the room. It was in 1843 that he first came into contact with Mr. Elkington, of Birmingham, and began to move in the domain of applied electricity. They had seen the telephone doing its wondrous work in carrying their voices to great distances, and they had now to witness the power of electricity in carrying them along in a tramcar. The electric railways with which he had been connected had run at the rate of twenty-five miles an hour. In Ireland one had lately been inspected by General Hutchinson, and was just about to be opened for traffic. The tramcar had to carry its own store of power. This would be charged into the car at convenient stations. Such a car would run upon common roads as well as on railroads. A much smoother movement was experienced in a tramcar propelled by electricity than that in an ordinary tramcar.

Mr. NOEL, M.P., in proposing "Success to the Electrical Power Storage Company," said:—Great as the advances in electricity have been, we have not yet discovered the means of effectively storing power when it has been generated. Once get the power of storage and it can be used in large or small quantities. He coupled with this toast the name of Mr. Sellon, one of the inventors, a gentleman with an intense love of science, and one who had devoted a great many years of his life not only to science generally, but to electrical science in particular; also the name of Mr. Volckmar as a co-operator.

Mr. SELLON, in reply, gave a detailed account of the work and estimated cost as applied to tramcars. After referring to difficulties encountered, and he hoped overcome, he went on to speak of the economy of electricity. In round figures it might be taken that, by the employment of electrical apparatus, an effective return of 50 per cent. was secured out of the steam horse-power taken from the stationary steam engine, and if the latter cost one halfpenny per hour the effective horse-power on the pulley of the working motor was obtained at as low a cost as one penny per hour. Assuming that each ton of weight of a tramcar with its load required one horse-power traction, an average force of five horse-power would be more than sufficient for a car and 40 passengers, and taking the working day of a car at 15 hours, the cost is shown at 75d. for 75 horse-power hours, or, in other words, 6s. 3d. per day for traction. The actual daily cost of horsing a tramcar was given by some of the metropolitan companies at 26s. The difference between the 6s. shown above as the cost of electrical power, and the 26s. paid for horses affords such a margin that, after abundantly providing for sinking fund, depreciation, repairs, contingencies, &c., a very great saving is effected. Another great public convenience was obtained in the means of lighting the car from the same accumulators used for the motive power. Where water or other natural power might be brought to bear there was no daily consumption of fuel, and the only outlay was really the sinking fund for depreciation of the machinery.

The following information has been supplied by the Electrical Power and Storage Company:—"This tramcar is fitted with an accumulator consisting of 50 Faure-Sellon-Volckmar cells, each measuring 13in. by 11in. by 7in., and weighing about 80lb. The accumulator is capable of working a tramcar with its full load for half a day, or in other words seven hours. When charged it contains about 560 ampere hours, of which 400 are withdrawn with the greatest regard to economy. The accumulators are stored under the seats of the car, and the current is communicated by insulated wire to a Siemens dynamo machine acting as a motor, and connected with the axle of the wheel. Therefore, as soon as the communication between the boxes and the dynamo machine is effected, the electric current being led into the dynamo motor sets the armature of the motor in revolution, and the power is conveyed to a pulley fastened on the same axle as the armature. The Siemens motor works most favourably with an electric motive force of 100 volts and a current of 60 amperes, equal to 6,000 volt-amperes or watts, and as 746 watts constitute an electrical horse-power, the result is a consumption of eight electrical horse-power, and a yield on the pulley of five and three-fifths electrical horse-power. The action of the motor may be reversed at will, and the power may be increased or diminished as required by adding to or taking from the number of cells composing the accumulator by means of a simple switch, and by breaking the circuit the motive power is stopped, and the break being then applied the car is almost immediately brought to a standstill. The cost of horse-power produced from a stationary steam engine of large size has been ascertained and is universally accepted as one halfpenny per horse-power hour. Five hundred steam horse-power would, therefore, cost 250 pence, equal to £1 0s. 10d. per hour. This power would be applied to the working of electro-dynamo or generating machines. One of the best-known inventors claims that he can supply a dynamo which will give an effective return of 95 to 97 per cent. of the power given to it. Without calling in question the accuracy of this pretension, it would be obviously unfair to adopt it as the basis of a calculation, and as there are many dynamo machines in the market which give a return of over 80 per cent., that is a more certain proportion to work upon. From 500 steam horse-power given to the dynamo, a return would therefore be obtained of 400 electrical horse-power. The dynamo would be worked to charge electrical accumulators, which in turn work an electric-dynamo motor machine from the fly-wheel of which the direct power is obtained. It is ascertained that when 25 per cent. of the maximum charge which the accumulators are constructed to receive is permitted to remain in them they attain their best working efficiency, and the 75 per cent. may be withdrawn at a loss of not more than 10 per cent. on the quantity so withdrawn. Of the 400 electrical horse-power given by the dynamo to the accumulator, the accumulator would give to the motor 360 electrical horse-power. The Siemens dynamo when used as a motor gives a return of 75 per cent. of the energy put into it, but taking only 70 per cent. the 360 electrical horse-power given by the accumulators to the motor will yield on the pulley of the dynamo 252 effective horse-power. In round figures, consequently, it may be taken that by the employment of electrical apparatus an effective return of 50 per cent. is secured out of the steam horse-power taken from the stationary steam engine, and if the latter cost one halfpenny per hour the effective horse-power on the pulley of the working motor is obtained at as low a cost as one penny per hour. Assuming that each ton of weight of a tramcar with its load requires one horse-power traction, an average force of five horse-power would be more than sufficient for a car and forty passengers, and taking the working day of a car at fifteen hours, the cost is shown as seventy-five pence for seventy-five horse-power hours, or, in other words, 6s. 3d. per day for traction. It must be borne in mind also that out of the fifteen hours there would be about three hours' stoppages, and that the electrical energy is only expended when the car is actually in motion. If the question be asked, "What are the relative initial or first costs of horses, steam, and electrical machinery for tramcars?" the answer is that they will be almost identical, but that the last named will have the advantages of requiring less space and a smaller number of assistants, combined with an immunity from those epidemics which at times incapacitate the stud of a tramway company. The actual daily cost of horsing a tramcar is given by some of the metropolitan companies at 26s. The difference between the 6s. shown above as the cost of electrical power and the 26s. paid for horses affords such a margin that after abundantly providing for sinking fund, depreciation, repairs, contingencies, &c., a very great saving is effected. Another great public convenience is obtained in the means of lighting the car from the same accumulators used for the motive power. Where water or other natural power may be brought to bear there is no daily consumption of fuel, and the only outlay is really the sinking fund for depreciation of the machinery."

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Thursday at St. Michael's Hall, George-yard, Lombard-street, Sir Henry Drummond Wolff, M.P., in the chair.

Mr. R. M. CUNNINGHAM (the secretary) having read the notice convening the meeting,

The CHAIRMAN said—Now, gentlemen, I will detain you as short a time as I can in bringing before you the business of the meeting. In the first place I shall have to propose that a dividend be declared at the rate of 3 per cent., to which, I suppose, no opposition will be raised, and after that certain resolutions will be submitted to you by shareholders with regard to the division of the shares. Now, I shall merely wish to say one word with regard to that division. On a former occasion, at the request of shareholders—certain shareholders—these resolutions were submitted to you, and at that time great objection was raised to them by certain of the shareholders present, who brought forward arguments against this division. We had a very large number of proxies at that time in our possession, but in consequence of the opposition that was manifested by the meeting, the directors thought that they would not be justified in using those proxies until the shareholders had had the subject more fully put before them. Afterwards a certain number of shareholders, according to the statutes, holding a certain number of shares, requisitioned the Board to bring this question once more before a general meeting of shareholders, and I may say, without expressing any opinion one way or the other on this division, that the directors had no alternative, even had they wished to have one, in calling a meeting, and submitting these resolutions to you, and giving the opportunity to the shareholders who were in

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favour of it to submit their views before their brother shareholders. We desired to put the question fairly before the proprietors, as, in our opinion it is entirely a question for the shareholders to decide. The duties of the Board are to manage the affairs of the Company, and not to propose to alter the shape in which the property is held; but these shareholders, holding, as you are informed, over 11,000 shares, have sent us a requisition, and we then determined to send the proxies out in such a form as would give every shareholder the opportunity of recording in which way he considered it right the decision should be come to. Well, without going into any question of statistics, I may say that the proxies that have been specially noted as in favour of the resolutions are about five times in number to those which are against them. I say the directors have exercised no influence to procure that result, but the shareholders have spontaneously sent their proxies in.

Mr. BURT: Do you mean five times the number of proxies or of votes?

The CHAIRMAN: Of votes. I merely inform you that to tell you that this is a question for you to decide, and we have no alternative but to use the proxies in the way the shareholders have directed us to do. I will now move that a dividend of 3 per cent. on the reduced capital of the Company, for the year ending 30th September, 1882, be, and the same is hereby declared payable on the 16th inst.

Major WOOD: I have much pleasure in seconding that.

The resolution was put and carried unanimously.

Mr. HERRING said that in the course of his life he had had many resolutions to propose, but he had never felt greater pleasure than he experienced on the present occasion. He believed that the division of the shares into preferred shares and deferred shares would put money into his pocket, and into the pockets of his fellow shareholders. Many arguments had been urged against the operation which it was now proposed to make, but he would only notice two; one was that the proposal was rather absurd, because the deferred shares would be only worth a few shillings, but he believed the result would show that they would be worth a good deal of money. Then it was contended that the conversion of the shares into the two different denominations would promote gambling on the Stock Exchange, but the Stock Exchange had to deal in other matters besides the shares of the Western and Brazilian Telegraph Company. He thought the shareholders ought to consider their own interests, and not whether the proposal would induce speculation or not. He even thought that if the deferred shares were bought by speculative men they would advance the interests of the Company, because what they wanted was energetic men. He thought the division of the shares as proposed could not possibly do any harm, but that on the contrary it would do good by introducing a further number of shareholders which would be the means of promoting the prosperity of the Company. In conclusion, he moved a series of printed resolutions having for their object the division of the shares into deferred and preferred shares.

Mr. WOOD seconded the resolutions.

Mr. BURT asked if there was any precedent for dividing shares so that one half, the deferred, should have a cumulative dividend.

Mr. BOMPAS (the solicitor) thought it was well known to all those who had had to deal with preferred and deferred shares, that it was usual for the deferred shares sometimes to have a cumulative dividend, and sometimes not. The advantage of a cumulative dividend was that there was no competition between the two classes of shareholders. With regard to their being any precedent for the proposal, the Great Northern B shares were cumulative.

Mr. BURT said that he was satisfied that the directors would find that instead of this measure uniting the shareholders it would cause dissention, and the result would be great difficulties to the board. He thought the directors themselves should have expressed some opinion on the subject. He believed the movement was made in the interest of speculators on the Stock Exchange, and that it would result in many questions of litigation. No doubt there would be disputes as to the amount applied to the reserve fund, because this property was running away every year in value, and arrangements would have to be made for replacing the cables. One man would want his dividend immediately, and another man would say that he would rather wait so that there would be two competing interests. He thought the matter would bring about great trouble to the directors.

A SHAREHOLDER asked whether the proposal was likely to interfere with the negotiations with the Brazilian Government.

The CHAIRMAN replied that the negotiations were at present in abeyance. In reply to Mr. Burt, he wished to say that the directors did not wish to put themselves in the position of having to defend or attack the present proposal. They considered in January that they were more than justified in submitting the resolutions to the general meeting from the very influential and powerful representations that had been made to the Board, and which were so numerous and so repeated that they would not have been doing their duty if they had not submitted the resolutions to the shareholders. With regard to the requisition, he did not think that they had anything to do with the profession of those who had signed it.

Mr. MORRISON pointed out that it was quite optional to any shareholder to convert his shares or not, and, therefore, as he could retain his shares, if he chose to do so, in their present shape, he could not possibly be hurt by the present proposal.

The CHAIRMAN, in reply to a question, said that whenever a proposition came from the Brazilian Government for the purchase of the line, it would be submitted to the shareholders.

Mr. HERRING having further advocated the proposal,

The resolutions were put to the meeting and carried, 14 voting for and 7 against them.

A poll was demanded, the result of which was 2,214 votes for the resolutions, and 4,322 against them.

The proceedings then terminated in the usual manner.

THE GERMAN UNION TELEGRAPH AND TRUST COMPANY (LIMITED).

The twelfth ordinary general meeting of shareholders of the German Union Telegraph and Trust Company (Limited), will be held at the offices of the Company, 66, Old Broad-street, London, on Wednesday, the 21st inst., at 12 noon, when the following report of the directors will be presented:—

The directors beg to submit the accounts and balance-sheet for the twelve months ending 31st December, 1882, including in the accounts the coupon in respect of that date just received from the German Union Company of Berlin. The total receipts during the twelve months amount to £11,427 12s. 3d., which, with a balance of £11 0s. 4d. brought forward from last account, make a total of £11,438 12s. 7d. The working expenses for the same period amount to £787 12s. 9d., leaving a balance of £10,650 19s. 10d. Out of this amount an interim dividend of 5s. 9d. per share was distributed on the 21st January last, and the directors recommend the payment of a further dividend of 4s. 10d. per share, making a total distribution for the year of 10s. 7d. per share, free of income tax, or at the rate of £5 5s. 10d. per centum per annum, leaving a balance of £41 4s. to be carried over to the next account. The reduction in the dividend now payable arises from the interruption of the Lowestoft-Emden cable from January to the middle of March, 1882, and to the increased working expenses consequent upon the establishment of the Emden-Valentia line. Since that line was opened the traffic has shown a satisfactory increase. The Lowestoft-Emden cable has worked well since its repair, and the Emden-Valentia cable is also in good working condition. The cable house at Lowestoft was washed away by a gale on the 5th inst., but temporary arrangements have been made by which the communication is maintained. A new cable house will be built forthwith. The preference capital issued by the German Union Telegraph Company of Berlin was fully subscribed, and the first year's interest coupon paid by this Company as their London agents in January last. According to the Articles of Association, Sir James Anderson, one of the directors of the Company, retires by rotation, and, being eligible, offers himself for re-election. The auditor, Mr. Henry Dever, also retires, but offers himself for re election.

ELECTRICAL POWER STORAGE COMPANY.—According to the report of the directors the principal work has been hitherto the sale of the company's patent rights to other companies abroad and the promotion of inventions, but it has likewise done a good deal in the way of demonstrating the practicability of the efficiency of the accumulators. The profit and loss account shows a balance of cash and shares of £346,930, but the most part of this is shares and royalties payable by instalments, so that no distribution is to be made at present. The directors, however, recommend that the preliminary expenditure of £16,819 should be written off at once. Altogether, it has paid £516,907 in shares and cash for the patents it holds.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES MAR. 14.		BUSINESS DONE WEEK ENDING MAR. 14. Highest.	Lowest.
Anglo American	51¼,	52½	51¾	50¼
Do. Preferred	83,	84	83	82
Do. Deferred	20½,	21	20¾	19½
Brazil Submarine	12⅛,	12⅜	12 11-16	12⅛
Cuba	10,	10½	10½	10½
Do. Preference	16¼,	17½	—	—
Direct Spanish	5½,	6	6¼	5½
Do. Preference	16,	17	—	—
Direct United States Cable	12⅛,	12¾	12 11-16	12⅜
Eastern Telegraph	10¾,	11⅛	11 1- 6	10¾
Do. 6 per Cent. Preference	13,	13½	13 5-16	13⅛
Do. 5 per Cent. Debentures, 1899	103,	106	105½	105½
Eastern Extension	11⅝,	11¾	11 13-16	11 11-16
German Union	10¾,	11½	11	11
Globe Telegraph and Trust Company.	6⅜,	6½	6¾	6¾
Do. Preference	12⅜,	12⅝	12 15-16	12⅜
Great Northern	12⅜,	12⅝	12¾	12⅜
Indo-European	32½,	33½	—	—
Mediterranean Extension	1⅛,	2	—	—
Do. Preference	7,	8	—	—
Reuter's	10½,	11	10¾	10¾
Submarine	247,	252	247	247
West India and Panama	1½,	1⅝	—	—
Do. 1st Preference	7½,	7¾	7⅝	7 9-16
Western Brazilian	7½,	8⅛	8	7⅝
West. Union 7 per Cent. 1st Mortgage	122,	126	—	—
Do. 6 per Cent. Sterling Bonds	102,	105	104½	104½

TELEPHONES.

Consol. Telephone and Maintenance	⅞,	1⅛	1	15-16
Oriental	⅛,	¼	¼	¼
United Telephone	11⅝,	12⅛	12 3-16	11⅝

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	6¾,	7¼	7⅛	6¾
Do. (fully paid)	9⅛,	9½	9¾	8¾
Hammond Light	3¾,	4	4	3¾
Eastern Electric (£5 paid)	1,	1⅛	—	—
Pilsen, Joel, and General Electric	½,	1	—	—
Swan	1⅞,	2⅛	2 1-16	2
Maxim-Weston	¼,	⅜	7-16	⅜

TRAFFIC RECEIPTS FOR FEBRUARY, 1883.

COMPANIES.	Feb., 1883.	Feb., 1882.	Increase.	Decrease
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,900	3,271	629	—
Direct Spanish Telegraph Company	1,544	2,109	—	565
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	46,667	44,046	2,621	—
Eastern Extension Telegraph Company	29,391	27,473	1,918	—
Great Northern Telegraph Company	17,800	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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SLIP

THE BLACK SEA CABLE.—The cable between Odessa and Constantinople is now restored.

THE SPERRY ELECTRIC LIGHT COMPANY.—This recently-formed company is reported to be establishing large works in Chicago.

EXPORTS.—The value of telegraphic wires and apparatus exported from this country during last February amounted to £22,738.

PROVISIONAL ORDERS.—The application for provisional orders under the Electric Lighting Act in respect of Northfield and Belfast have been withdrawn.

THE FYFE-MAIN ARC LAMP.—Twelve Fyfe-Main arc lamps of 3,000 actual candle-power have been selected to light the Houses of Parliament, Sydney, New South Wales.

UNDERGROUND WIRES IN NEW YORK.—The New York State Senate has passed to its third reading the Bill compelling all telegraph, telephone, and electric light wires to be put underground.

APPOINTMENT.—Mr. Alfred R. Bennett has resigned his post as engineer to Messrs. D. and G. Graham, of Glasgow, and has been appointed engineer for Scotland and Ireland to the National Telephone Company.

THE WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The directors of this company had an interview with Lord Derby, on the 20th instant, in order to obtain, if possible, some support in the shape of a subsidy.

THE AUSTRALIAN CABLES.—The Eastern Telegraph Company notifies the restoration of telegraphic communication with Australia. Further repairs to the cables are, however, still necessary, and these may cause another temporary interruption.

SCIENCE AND ART DEPARTMENT, SOUTH KENSINGTON.—The 1883 examinations of this department are announced to be held as follows:—Sound, Light, and Heat, on 8th May, from 7 to 10 p.m.; Magnetism and Electricity, 9th May, from 7 to 10 p.m.

THE POST OFFICE.—The Edison Company is about to extend the existing electric light arrangements by an additional 1,500 lamps for use at the Post Office. The current for these lamps will be supplied from the Central Station, at the Holborn-viaduct.

MACMAHON'S TELEGRAPHIC NEWS COMPANY.—It is notified that a general and final meeting of this company is to be held at 10, Old Jewry-chambers, E.C., on the 23rd April, at 2 p.m., to receive the liquidators' accounts showing how the winding up has been conducted.

PRIVATE TELEPHONIC COMMUNICATION.—It is stated that a contract has been entered into between the Postmaster-General and Mr. John Burns for special telephonic communication between Glasgow and Mr. Burns's residence, Castle Wemyss, Wemyss Bay, a distance of 31 miles.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending March 9, 1883, were £3,118, and for that ending March 16, £2,882, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE "CALABRIA."—The telegraph steamer "Calabria," belonging to the Telegraph Construction and Maintenance Company, which has been employed in transport work since the beginning of the Egyptian campaign, arrived at Portsmouth on Monday, having left Alexandria on the 6th inst.

THE UNITED TELEPHONE COMPANY.—This company give notice to their exchange subscribers that they have decided to take advantage of the Easter holidays by closing their exchanges on Saturday, the 24th inst., in order to enable the company to carry out extensions rendered necessary by the large increase of the business.

THE LAW COURTS CHAMBERS.—This huge pile of buildings, situate opposite the new Law Courts, at the entrance of Lincoln's Inn-fields, is to be lighted by Swan lamps. The electrical work is being carried out by Messrs. Crompton and Co., for the Swan Company. The same firm is also carrying out the general engineering work of the building.

WIRES IN CHICAGO.—All the wires of the Mutual Union Telegraph Company, in Chicago, were cut by order of the mayor on the 2nd inst., because the provision of the franchise which required the company to put its wires underground by March 1 had not been complied with. The wires of the Board of Trade Telegraph Company were also cut.

BOOKS RECEIVED.—"Die Galvanischen Batterein Accumulatoren und Thermosäulen," &c., von W. Ph. Haunck, and "Die Elecktrischen Beleuchtungs Anlagen," von Dr. Alfred von Urbanitzky, being Vols. IV. and XI. respectively of the "Electrotechnische Bibliotek," published by A. Hartleben, of Vienna, Buda Pesth, and Leipzig. Price, 3 marks each (about 3s.).

THE SAMARA SUGAR ESTATE.—Messrs. R. E. Crompton and Co. have received the order to light the works on this estate by means of the electric light. This work is but a small part of that being carried out by the firm in Russia. Quite recently apparatus has been sent there by them to light several mills in and around Moscow, supplying electric current for about 1,000 Swan incandescent lamps, and about 60 arc lamps.

SS. "TARAWERA."—The Edison lighting plant on board this steamer, belonging to the Union Steamship Company of New Zealand, is reported to have worked well on the voyage from Greenock to Melbourne. Only 10 lamps out of a total of 150 gave out during the voyage. As the loss of lamps during the first few weeks after the starting of an installation generally averages higher than that which occurs after the plant has been in use for a short period, owing to the weeding out of defective lamps, the result stated above may be reckoned as very satisfactory.

NEW COMPANIES.—The following companies have been recently incorporated, viz.:—The Edison Light Company of Milwaukee, with a capital stock of 200,000dols.; the Bernstein Electric Light Company of Eastern New Hampshire, with a capital of 100,000dols.; the Electrical Accumulator Company of New York, capital 50,000dols.; the Overland Telephone Company, New York, capital 1,000,000dols., with power to be increased to 10,000,000dols; and the Sun-light Company, New York, for lighting by electricity and transmission of electric power, capital 5,000,000dols.

ELECTRIC LIGHTING FOR VIENNA.—A Reuter's telegram from Vienna, dated Wednesday, March 21, says:—Negotiations are going on between the Brush Electric Light Company and the Vienna Town Council respecting the lighting of this city. The company offers at its own expense to lay cables in every part of Vienna in return for the exclusive privilege of supplying the electric light here for a period of fifty years, whether for public or private purposes. Public opinion, however, is against such an arrangement, and it appears unlikely that the company will succeed.

THE EDISON SYSTEM IN MOSCOW.—A correspondent writes from Moscow, under date March 10:—"We have

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several installations of the Edison light here at Moscow, erected under the superintendence of Mr. J. J. Robins, the engineer and representative of the company. One large cotton mill is completely lighted with 320 of the A lamps, and other installations are in course of being carried out. This light proved also a complete success at a large ball lately, where forty B lamps gave a good light from six p.m. to seven in the morning without a flicker. The current was supplied from an Edison E dynamo."

PHOTOGRAPHY BY ELECTRIC LIGHT AT NIGHT.—During a fancy ball recently given at the Queen's Hotel, Eastbourne, Messrs. Lavers and Co. most successfully photographed 120 of the guests in their fancy costumes. The lighting of the studio and ball room was carried out by the Eastbourne Electric Light Company, under the direction of Mr. H. M. Sayers, the Company's electrician and manager. The whole installation was provided at a few hours' notice, and was removed before 10 a.m. the following morning. Mr. Sayers, who has been with the Eastbourne Company from its commencement, was warmly complimented on the success of his work.

UNITED TELEPHONE COMPANY v. HERDEN.—Our readers will remember that the defendant in this case was, as reported in our last week's Notes, committed to prison for contempt of court in disobeying an order restraining him from supplying certain telephonic instruments in infringement of the plaintiffs' patent. His counsel appeared before Mr. Justice Fry on the 15th instant, stating that the defendant humbly apologised for the contempt he had committed, and expressed his deep contrition.—Mr. Cozens Hardy, Q.C., on behalf of the plaintiffs, left the matter in the hands of the Court.—His lordship thought, under the circumstances, that the apology tendered was sufficient, and ordered the prisoner to be discharged.

THE LIGHTING OF LIGHTHOUSES.—In the House of Commons on Monday last Mr. Chamberlain, in answer to Mr. Dawson, said that the committee on lighthouse illuminants had already held some meetings and made considerable progress with its arrangements. It had been thought desirable to increase the scope of the inquiry, and he could not say exactly on what day the proposed experiments to test the relative powers of gas, oil, and electricity would take place, because that would depend on the weather and many other circumstances; but he had no reason to believe that any time would be lost. It is probable, we may add, that Professor Tyndall and Dr. Siemens will be members of the above-mentioned committee.

ELECTRIC LIGHTING FOR DUNDEE.—We have reason to believe that the town of Dundee has arranged with the Brush Company to light the streets. A 250 horse-power steam engine is to be put in hand as soon as a suitable permanent building can be prepared. The town allows four years for the execution of the lighting work. At present, as has been stated in *The Electrician*, there is a small Brush installation at work in Commercial-street. It is owing to the admirable way this has been managed that the larger order is now given. The installation consists only of a portable Robey engine and six-light dynamo (Brush) on one bed plate. The lamps are on posts in the centre of the street. On a recent visit we observed that the steadiness of the light was very great, a result due to Mr. Morton's care and supervision.

THE THERMO-ELECTRIC POSITION OF IRIDIUM.—At the eighth meeting of the Royal Society of Edinburgh held this week, Professor Tait gave an account of some experiments made by himself "On the Thermo-electric Positions of Pure Rhodium and Iridium." His purpose in following out these experiments was, he said, to discover two metals which should give lines on the thermo-electric diagram parallel to that of lead, or which, in other words, should have no Thomson effect, but which, at the same time, should be so far apart as not to be within the limits of experimental error; and so to be enabled to construct a thermo-electric thermometer. He had found that rhodium and iridium fulfilled the first condition, but that, unfortunately, their lines almost coincided. He meant to pursue his experiments with the metals allied to platinum in the hope of finding the desired result.

A NEW CABLE.—A correspondent sends us the following extract from the Portuguese *Official Gazette*:—"Mr. Jean André Braam has signed a contract with the Government for the laying and working of a submarine cable from Portugal to the Western Islands (Azores), and from thence to America, Great Britain, France, and Spain. He has deposited £800, which can be taken up on the commencement of regular working between Portugal and the Island of St. Miguel. The concession is for the space of twenty years, the cable to be in complete working order between Portugal and the Island of St. Miguel in the space of one year, from thence to one of the American States in eighteen months, between St. Miguel and Great Britain in three years, and between the island and France and Spain in four years. Tax per word between Portugal and the islands not to exceed half-a-franc. For telegrams between the Azores and England or France the rate to be authorised by Government."

THE BRUSH LIGHT IN THE CITY.—At a meeting of the Commissioners of Sewers, on Tuesday, Mr. Deputy Pepler presented a report from the Streets Committee, recommending that the contract with the Brush Electric Light Company be continued for another year on the present terms and conditions, except that power be reserved to the commission to terminate the arrangement at any time within that period by 90 days' notice. The report was agreed to, as was also another report by the same committee relative to Sugg's experimental gas lighting in Fleet-street, and Siemens's patent experimental gas lighting in Holborn, stating that, having regard to the increased cost, they are not prepared to advise the adoption of the systems, but recommending that the reports of the engineer be printed for the information of the commissioners. So it seems, after all, that increased light by means of gas is not to be had without paying the piper, and that to a tune so unaccustomed that the rulers of the City "are not prepared to advise the adoption of the systems."

LEGAL.—The case of "The Plating Company *v.* Farquharson and others (trading as The Nickel Plating Company)" came before the Lord Chancellor and Lords Watson and Fitzgerald on the 15th inst. This was an appeal from a decision of the Court of Appeal reversing a judgment of Vice-Chancellor Bacon, pronounced in an action brought by the appellants as plaintiffs against the respondents for the alleged infringement of certain letters patent relating to nickel plating. The appellants, who carry on business in Hatton-garden, are the owners of certain letters patent, known as Adams's patent, granted to William Brookes for the invention of improvements in the electro-deposition of nickel, communicated from abroad by Isaac Adams, jun., of Boston, in the United States. The respondents, who are also electro-platers, carry on business at Greek-street, Soho, and it was alleged that in the process of nickel-plating they had infringed the appellants' patent. The Court below decided that there had been no infringement of the appellants'

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patent. Their lordships, without calling upon the respondents, dismissed the appeal, with costs.

Electric Lighting in America.—We take the following items of news from our New York contemporary, the *Sanitary Engineer*:—"The City Council of Dayton, O., adopted, Feb. 23, a resolution accepting the proposition of the Fuller Electric Light Company to light the city for one year.—The streets of Seabright, N.J., and the ocean boulevard are hereafter to be lighted by electricity at the expense of the wealthy cottagers and hotel people.—The Arnoux Electric Light Company has received an order to furnish light for the United States and Canadian departments at the Fisheries Exhibition to be held in London.—The telephones in the fire engine houses in Newark were burnt out Sunday night, by contact of the fire department wire with an electric light wire. The woodwork in the office of the superintendent of fire alarms was set fire to.—A recent conference was held in Boston between many prominent men of that city and the officers of the Edison Electric Light Company of this city, to consider the project of establishing an Edison plant in Boston like that in operation here.—The Thomson-Houston system of electric lights is being introduced into Utica, fifty-four lights having been subscribed for by merchants.

A Sulphate of Copper Battery.—A new form of battery devised by M. Callaud is now made by Messrs. Dumoulin and Froment, of Paris. It is made up as follows:—Sulphate of copper is placed in a glass jar, in the bottom of which are two holes. The positive pole is formed by a copper wire, rolled in the shape of a spiral at its lower end, and is without weld, solder, or any break in its continuity. A protection of rubber, sufficiently thick, formed by a simple tube slipped over the end of the copper wire, covers it from the bottom to outside the outer jar. The zinc is suspended by two hooks, which are passed through two holes made in the top of the jar, and rest on the edge of the outer jar. This battery, says *L'Electricien*, has one peculiarity which can be of a certain use as regards attending to it—namely, the difference generally noticed between the level of the liquid inside and outside of the glass jar. If the battery is in good condition, the liquid in the jar is lower than that with the zinc, thus showing that the solution of sulphate of copper is concentrated, or nearly so, and that of zinc sulphate is not so. This case proves the battery to be in good working condition. If, on the contrary, the heights of the liquids are equal, or even if the sulphate of copper should be higher than the other, it is because the copper solution is not concentrated enough, or that the sulphate of zinc solution is overcharged with salt. The constants of the battery thus made do not differ at all from those of the ordinary Callaud (E = about 1 volt, R = 6 to 8 ohms), because the positive pole is always kept in the solution of sulphate of copper, which escapes from the jar through the two holes.

Oxidation-products of Carbon obtained by Electrolysis.—An abstract of a paper by A. Millot in the *Bull. Soc. Chim.* appeared in a recent number of the *Journal of the Chemical Society*. According to the author gas carbon electrodes are much more rapidly attacked in alkaline solutions than in pure or acidulated water. The dark solution obtained by the electrolysis of a 5 per cent. solution of ammonia with gas-carbon electrodes becomes acid on evaporation. It contains ammonium nitrate and an acid which may be isolated by evaporating almost to dryness, heating the precipitated black matter with alcohol, and evaporating the alcoholic solution, when crystals of the ammonium salt of the acid, mixed with ammonium nitrate, separate out. The crystals are dissolved in water and mixed with lead nitrate which produces a crystalline precipitate. This precipitate is suspended in water, treated with hydrogen sulphide, the solution filtered from lead sulphide and evaporated, when the acid separates out in needles. Its composition will be determined when a sufficient quantity has been obtained. The black matter precipitated by the addition of an acid to the solution obtained by the electrolysis of a 2 per cent. solution of potassium hydroxide has the composition O 37·72; C, 58·65; H, 3·27; N, 0·56. The whole of the nitrogen was evidently not removed from the carbon electrodes, although the latter were treated with chlorine for 150 hours. The black substance is soluble in boiling water even after being dried at 100deg., but is precipitated by ebullition in contact with air. It is insoluble in alcohol, ether, benzene, and chloroform. When an aqueous solution of the black substance is treated with a current of air, it absorbs a considerable quantity of nitrogen, which, however, is again partially removed by continued passage of the air, the substance at the same time being oxidised and destroyed.

International Electric Exhibition at Vienna.—From information received from the head-quarters of this exhibition in Vienna it seems that it is likely to prove a good one. The following list of names of intending exhibitors that have been received will be interesting:—Italy will be represented by the Societa Anonima Generale Italiana dei Telefoni, of Naples, with a collection of lighting apparatus and telephones; Alessandro Lucchesini and Jules Lorenzelli, of Florence, with various telegraphic apparatus; Rialti Vincenzo, of Forli, with many novelties in incandescent lamps; Dr. Charles Labus, of Milan, with his laryngofâtome for demonstrating laryncoscopic operations; and Dr. Samuele Salaghi, of Rome, with electro-therapeutic apparatus. We may next mention France, which will be represented by the Maison Breguet and L. Sautter, Lemonnier, and Co., of Paris, both world-renowned firms. The former firm are known as one of the oldest makers of telegraph apparatus; now, however, to keep abreast with the times, they are manufacturing lamps, dynamo-machines, galvanoplastic apparatus, &c. The exhibits of L. Sautter, Lemonnier, and Co. will include a lighthouse; besides this, they have promised to send eight dynamo machines, ten large reflecting apparatus, and a great number of electric lamps. M. Lazare Weiller, of Angoulême, will show his wires, &c., of silicium phosphor bronze and copper; and Ch. Ferd de la Roche, of Paris, regulators and incandescent lamps. Switzerland will be represented by Emil Bürgin, of Basle, and the Swiss Edison Company. Herr Paul la Cour, of Askovhus, Denmark, the inventor of telegraph apparatus, and Wilhelm Helle, sen., of Copenhagen, inventor of telephones, have promised to exhibit. From Germany will come the firm of Keiser and Schmidt, of Berlin; the Rheinische Electricitäts-gesellschaft, of Mannheim; C. H. F. Müller, of Hamburg; and Heilmann-Ducommun and Steinlen, of Mühlhausen, whose exhibits at Paris will be well remembered. They will, amongst other things, show the application of electric power to ordinary workshop machinery. Dr. Emil Boettcher, of Leipsic, will show secondary batteries; Josef Zimber, of Furtwangen (Baden), electric clocks; Michael Sendlner, of Munich, electric thermometers; Greiner and Friedrichs, of Stützerbach, (Thuringen), incandescent lamps; Dr. Greitner, of Auerhammer, cables; E. M. Reiniger, of Erlangen, electro-surgical apparatus; Dr. Albert Lessing, of Nurnberg, various apparatus; Dr. Johann Wilckens, of Bremen, a Droste's type-printing telegraph; and Spiecker and Co., of Cologne, dynamo-electric machines.

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AN ELECTRIC THERMOMETER.—M. Becquerel was engaged during the winter in experiments, the object of which was to ascertain whether snow had the effect of protecting the ground from frost. In carrying out these experiments he pressed electricity into his service in a most ingenious manner. Before describing his apparatus, we may, however, state that the result of his experiments was as follows:—That a covering of snow does not protect the soil and seed from freezing, but only hinders to a certain degree the too extensive radiation of heat from the soil, and is converted into water at 32deg., which sinks into the earth and somewhat raises its temperature. Also, that a heavy sod does more to protect the soil and raise its temperature than ever so thick a layer of snow. The experiments were carried out in the Jardin des Plantes, Paris, and in the following manner, according to our contemporary, the *Weiner Landwirthschaftliche Zeitung* for January last:—"Two covered wires of unlike metals—copper and iron—were soldered together at both ends, which were left uncovered for this purpose; otherwise they were covered their whole length, for the purpose of insulation, with gutta percha and silk. On the soldered ends of these double wires being exposed to different temperatures a current is generated in them, and the greater the difference in temperatures the stronger the current, but the current ceases when both are exposed to the same temperature. This electric current was caused to act on a magnetic needle suspended so as to move freely over a graduated circle, a kind of compass. The copper wire formed a vertical frame around the needle parallel to its normal direction. As long as both ends of the double wire are at the same temperature the needle continues to point to the north, being subject only to the earth's magnetism, but as soon as there is any variation in temperature the needle is sure to move instantly and take another position, which it will keep until some other change of temperature takes place. The application of this apparatus to the measurement of soil temperatures was made as follows:—One of the soldered joints was buried in the earth to a depth at which it was desired to take the temperature, and the other end was put in a water bath at any desired distance from the first. The temperature of the latter could be increased or diminished at pleasure, and was measured by a very sensitive thermometer. To ascertain the temperature in the soil where the other end was buried, it was only necessary to raise or lower the temperature of the water bath until the magnetic needle stood at zero, and then read the thermometer."

ELECTRIC LIGHTING AND THE BOARD OF TRADE.—A deputation of the Parliamentary Committee of the Board of Works for the Westminster District, introduced by Mr. W. H. Smith, M.P., and Lord Algernon Percy, M.P., had an interview on Thursday (March 15) with the President of the Board of Trade to ask for a postponement of the operation of the Electric Lighting Act of last Session, so far as Westminster is concerned, for a period of three years from the date of the passing of the measure. The views of the deputation were set forth in a memorial and were also stated by Mr. T. Horn, C.E., Mr. J. K. Aston, and Mr. Hamborg. They were to the effect that at present any proceedings taken under the Act must be of a speculative and experimental character; that no practical demand exists in the district for electric lighting, and unless it should be desired by a majority of ratepayers it ought not to be forced upon them; and that so far they did not possess sufficient experience as to which of the various schemes would be most beneficial to the public, or whether it would be more to the interest of the ratepayers to apply for a license on their behalf to adopt the new system or to allow provisional orders to be obtained by private companies. It was further contended that electric lighting did not at present commend itself to the public generally. The deputation suggested that the Government should bring in an Act containing general provisions for the supply of electricity, such provisions to be incorporated in any license or provisional order, and admitting of alterations from time to time should necessity arise for amending the private Acts of the patent companies. Chiefly and specially, however, the deputation urged that their object was to gain time, so that they might not be hampered in the future by the creation of vested interests, and they put in this plea not in the interest of the gas companies, but to leave themselves free hereafter to adopt whatever system might appear the best.—Mr. Chamberlain, in reply, said he would notice first the practical suggestion made, viz., that the Government should introduce a general Act containing provisions that might be introduced into Bills promoted by private companies. In his opinion nothing could be more inadvisable, having regard to the general principle of local government and to local circumstances, than such a proceeding. They had, as a matter of fact, already obtained the greatest possible security in this respect in the model clauses which had been prepared by the Board of Trade. It had been stated that the Act did not afford guarantee for continuous supply, nor safeguards as to price; but the contrary was the case. Continuous supply was compulsory, except that a period of six months' grace was allowed at the commencement of an installation, and the method of charging for the supply of electricity was ordered to be in accordance with one of three accepted systems. As to the question of postponing the operation of the Act, the proposal was virtually the same as was submitted to him before the measure was passed; but he was bound to say that to proceed in the way suggested would be in direct contravention of the principle of the Act. That principle was that the public should have the chance of getting the electric light, and if the local authorities were not ready to supply it others should be allowed to do so. In Westminster they might not be prepared to run the risk and to burden their rates with the cost of experiments; and if he were to express his private rather than his official opinion in the matter, he should say they were very wise in taking that view, and that they would not be justified in incurring any great expenditure. But that was no reason why they should stand in the way of private persons who might be willing to take the risk. The local authorities were amply protected. They could appear before the Board of Trade and take objection to any scheme proposed before a provisional order was granted, and after it is granted they would be in this strong position: If the experiment proved a success at the end of a few years—a really short term in the life of a municipality—they, as representing the ratepayers, could come in and take over the whole undertaking, merely purchasing the plant at its actual value at the time. Never before were such rights conferred by an Act of Parliament. They had security against the creation of a monopoly, while they were left free to watch an experiment carried out at the cost of other people. Under such circumstances he did not think it would be wise for any local authorities to put themselves in the way of the execution of the Act.—Mr. Horn explained that they did not wish to oppose themselves to scientific progress; all that they wished was time to consider the merits of the new system of illumination thoroughly.

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CURRENT ENERGY.—IV.

BY OLIVER HEAVISIDE.

We have arrived at three distinct expressions for the potential energy of currents, involving line, surface, and volume integrations. Thus, confining ourselves first to a pair of linear circuits, we started with a surface-integral, derived from the properties of magnetic shells, viz., the integral amount of magnetic force passing through one circuit due to the current in the other. This amount, multiplied by the strength of current in the circuit for which the integral is reckoned, is the quantity upon whose variations the mutual forces depend. Now, the idea of magnetic force as a vector or directed quantity has become so widely spread and utilised that it might appear that the expression of the energy in terms of the number of lines of force through a circuit was a very natural one. In all modern explanations relating to magneto and dynamo machines, the lines of force are much employed. Yet this form for the energy is very artificial, and, in that respect, is like some other forms. For, although we may frequently merely consider the lines of force of the field in immediate proximity to a conductor, and the manner in which they cross the wire when it is moved, or when the source of the field is moved, thus producing variations in the integral amount of force (or of magnetic induction, to use the more general term, when induced magnetisation, notably that of iron, not here considered, is operative) through a circuit, yet to reckon up the integral amount a knowledge of the strength and direction of the magnetic force just about the wire is not sufficient. We require strictly to know the magnetic force all over an imagined surface, with its edge coinciding with the linear circuit. Choose one side for positive, one direction through it for the positive direction, and then by integration over the surface find the excess of the amount of force going through it in one over that in the reverse direction. This process may become singularly complex when the circuit has not a simple form, owing to the extraordinarily involved character of the surface, through which a selected line of force may pass again and again. In practical applications, however, we may simplify the process. Thus, in the case of a coil of closely-packed windings, say n in number, since each winding forms nearly a closed curve in itself, we may imagine a separate surface for every turn of wire, thus reducing the problem without sensible error to that of n distinct circuits of simple forms placed in a magnetic field. The sum of the amounts of force through the individual surfaces will plainly be almost precisely the same as through a single surface whose edge is bounded by the real circuit.

By a transformation we next obtain the mutual energy in terms of line-integrations following the course of the current, with a result most succinctly expressed in Neumann's formula, given at the end of Art. I., and we are able to recognise the very simple manner in which the different current elements may be considered to contribute to the result; and, following this up, we arrive at simple expressions for the mutual and self-energy of arbitrary distributions of current in terms of the currents and their vector-potentials, which are exactly analogous to the formulæ for electrostatic energy. And, by another transformation, given in Art. III., we obtain the energy in terms of the magnetic force alone.

Now, if we change the sign of the quantity we have called the potential energy of a current, which is always negative (being $= -\Sigma B^2/8\pi$, equation 12, p. 391) we obtain a quantity which is necessarily always positive. Calling it T, so that we have $T = \frac{1}{2}\Sigma\overline{AC}$, where C is the current and A the vector-potential, it will be shown later that T expresses the capacity the system has for performing work, which may be of various kinds, in virtue of the existence of the current, so that T may be strictly called the Energy of the system. Taking this for granted for the present, in order not to enter upon inductive phenomena, we may, however, remark in passing that we calculated the polential energy ($-$ T) in exactly the same manner as electrostatic energy may be calculated, from the mutual forces, to wit. P being the electrostatic potential, and ρ the density of electrification, $\frac{1}{2}\Sigma P\rho$ is the potential energy of the electrification, corresponding to $-\frac{1}{2}\Sigma\overline{AC}$. Now, $\frac{1}{2}\Sigma P\rho$ really represents the capacity the electrified system has for performing work, that is, its energy. It is always and necessarily positive, and, when referred to the dielectric medium, may be considered to express the potential energy arising from elastic forces due to displacements of some kind. The fact that the potential energy M, in the electro-magnetic case, is negative (resulting from attraction of similarly directed currents) is sufficient to show that it cannot represent the capacity for work of the current system. Yet the variations of M do represent the mechanical forces. So do those of T, any increase of one being equivalent to an equal decrease of the other. Therefore T might be the energy. But it could not be potential energy, for that tends to decrease; for instance, two movable circuits tend to move so that their potential energy decreases, with currents constant, and, therefore, so as to increase T. If, then, T be the energy, and it cannot be potential, it must be kinetic. And it is true that, considered as kinetic energy, it follows from strictly dynamical principles that T would tend to increase (with unchanged currents) by the motions resulting from the actions upon movable parts. Without, then, any knowledge of inductive phenomena, we might hazard the conjecture that T represented the energy, and that it was kinetic; and from the properties of kinetic energy all the laws of induction would follow.

At present, however, let us merely examine how the different expressions for T tend to locate the energy. The original form (surface-integrals) is quite out of the question, even for a single linear circuit, to say nothing of an arbitrary system of current, whether in wires or diffused in large conductors.

The form $T = \frac{1}{2}\Sigma\overline{AC}$, however, is more definite. Here any unit volume where the density of the current is C contributes $\frac{1}{2}\overline{AC}$ to the total, and of course space, where there is no current, contributes nothing. The summation extends throughout the current. Now, we know that there is something going on in a wire conveying a current; we know, for instance, that there is a transfer of energy from a battery or other source of electricity; therefore, so far, it would not be unreasonable to suppose the energy resides where the current resides. But observe that, upon this view, the energy at any spot would depend not merely upon the current there, but also upon the vector-potential there, and the latter depends upon the state of the whole system. Now, the energy at any place, whether potential arising from elastic displacements of matter tending to return to neutral positions, or kinetic, due to a motion going on, would obviously depend on the displacements or motions at the place considered, and not upon those in all parts of the system. Evidently, then, the expression $\frac{1}{2}\Sigma\overline{AC}$ does not locate the energy properly. Notice, also, that although the total is positive, yet the portion $\frac{1}{2}\overline{AC}$ in any particular unit volume would be positive or negative, according as the current and vector-potential were similarly or oppositely directed, and zero should they be perpendicular. We may therefore dismiss the idea of $\frac{1}{2}\overline{AC}$ representing the energy per unit volume or density of the energy.

But we have still the form $\Sigma B^2/8\pi$ at disposal. This is identically the same in amount as $\frac{1}{2}\Sigma\overline{AC}$, but indicates a very different distribution of energy. In a unit volume we have the amount $B^2/8\pi$, B being the strength of magnetic force there. Being a square, it is always positive. Thus,

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not only have we the total positive, but every element of the sum is positive as well. And the energy at any place depends only upon the square of the magnetic force at the place, and not upon the state of all the rest of the system.

The conclusion is irresistible that we have got an expression for the energy which may correctly locate it in amount at different places. As to its distribution, although particular arrangements of current may be such as to leave certain spaces without magnetic force, yet, in general, the latter extends throughout all space. The portion of the energy residing in the space occupied by the current may be only a small fraction of the whole amount. And, even then, it depends on the magnetic force, and not upon the current density; although, of course, there is connection between the force and current in other ways.

[*Examples.*—In the case of a closed solenoid there is no external magnetic force. And if the current-layer be thin compared with the diameter nearly all the energy resides in the space enclosed by the current, and next to none in the current itself. In the case of a long, straight solenoid the internal energy is very great compared with the external; the force is uniform, of strength $4\pi C$, where C = current across unit length of the solenoid, except near the ends where the force falls off; hence the energy in any part of the internal space not near the ends is proportional to the volume.]

When, then, we set up a current in a conductor, a transmission of energy outwards at once begins, and not until it is completed does the current get steady. Theoretically it never quite gets steady, space is boundless, and the transmission of energy outwards never quite ceases; but, in general, the permanent state is, practically, reached very quickly, and then we have a definite amount of energy in every place where the magnetic force extends, falling off in density of distribution rapidly as we recede from the current. A medium of some kind to receive the energy is, of course, necessary.

If the energy be kinetic some kind of motion must be going on where there is magnetic force. One suggested form is a rotation of matter about the lines of force as axes. This should be of a frictionless character, for there is no loss of energy in a steady current except what can be accounted for in heating the conductor or by other work done. It is as if we had a frictionless fly-wheel, or immense number of fly-wheels somehow set moving by the establishment of a current in a circuit, and possessing in virtue of their motion a store of energy which can be afterwards utilised. The supply of energy from the battery may be stopped, and then the reserve store comes into action, is returned to the same wire, or to other conductors in its neighbourhood, creating the phenomena of induced currents.

But in the absence of reason to think the energy kinetic, we could equally well consider it potential, with the same distribution in space. We might, for instance, replace the steady motions of rotation last mentioned by displacements in the direction of the magnetic force, or by the same rotations as before, but stopped by counteracting elastic forces brought into play. The energy would be similar to that of a bent spring. On the removal of the E.M.F. that kept up the current, the forced state would be relaxed, the displacement cease, and the energy be set free again.

Before proceeding to the connection between energy and induction currents, we may notice some remarkable properties of the energy considered merely as expressing the quantity $\Sigma B^2/8\pi$ or $\frac{1}{2}\Sigma\overline{AC}$.

Let there be a given distribution of current C_1; corresponding thereto we have a definite distribution of magnetic force B_1, and also of vector-potential A_1. Briefly, they are related thus, $A_1 = \Sigma\frac{C_1}{r}$, $B_1 = \text{curl } A_1 = \Sigma\frac{D_1}{r}$ (if $D_1 = \text{curl } C_1$); and $4\pi C_1 = \text{curl } B_1$. All these relations have been fully explained. In addition we have $T_1 = \Sigma B_1^2/8\pi$, and B_1 being definite, so is T_1.

Consider the effect upon T of altering the magnetic force in any arbitrary manner, that is B_1 at any place is to be changed to some other value, say B, differing in general from B_1 both in direction and magnitude. We may make the alteration by bringing in another magnetic field, say B_2, of an arbitrary nature. At any point the actual magnetic force B will be the vector-sum of B_1 and B_2. Now T_1 becomes T where

$$T = \frac{1}{8\pi}\Sigma(B_1 + B_2)^2 = \frac{1}{8\pi}\Sigma B_1^2 + \frac{1}{8\pi}\Sigma B_2^2 + \frac{1}{4\pi}\Sigma\overline{B_1B_2} \quad (1)$$

$$= \quad T_1 + \quad T_2 + \quad T_{12} \text{ say.}$$

The energy is increased by $T_2 + T_{12}$. Here T_2 is the energy of the system B_2 by itself, and is essentially a positive quantity. But T_{12} containing products may be either positive or negative, so that whether the energy is increased or decreased is quite indefinite so far.

But now, instead of letting B_2 be quite arbitrary, let it be subjected to the condition that it shall not alter the current. We can then evaluate T_{12}. The original current C_1 must be still C_1, after the superposition of the second field, and no fresh current must be introduced in other places. C_1 being completely defined by the curl of B_1, it is evident that the condition imposed upon B_2 is that it shall have no curl anywhere.

If we have two *current* systems, we have seen that (equation 13, p. 391), $\Sigma\overline{B_1B_2} = 4\pi\Sigma\overline{A_1C_2}$, where B_1 and B_2 are the magnetic forces, A_1 the vector-potential of one current, and C_2 the other current. Therefore, if $C_2 = 0$, which involves curl $B_2 = 0$, we shall have $\Sigma\overline{B_1B_2} = 0$. This is suggestive, but does not exactly correspond to the circumstances considered in equations (1) above. For $C_2 = 0$ involves $B_2 = 0$; whereas in (1) B_2 is not to vanish, but merely to have no curl. Otherwise it may be arbitrary. Nevertheless, it may be readily shown that $\Sigma\overline{B_1B_2}$ really vanishes in (1) by considering the imposed property of B_2. When we say that its curl is nothing everywhere, we imply that nowhere can any closed curve be described so that the integral of B_2 once round it differs from zero. Now, B_1 consists entirely of closed tubes. Select one of them, and let it be of infinitely small section. The portion of $\Sigma\overline{B_1B_2}$ belonging to this tube is

$B_1 \times$ section of tube $\times$ integral of B_2 once round its length.

But $B_1 \times$ section is a constant for the same tube, and the last factor is zero, hence the portion of $\Sigma\overline{B_1B_2}$ is zero for that tube. Similarly it is zero for any other, and for all, and it follows that the whole summation $\Sigma\overline{B_1B_2} = 0$.

Consequently (1) becomes $T = T_1 + T_2$. Hence, if we alter the magnetic force of a current in any manner consistent with keeping the current the same, the energy is invariably *increased;* for T_2 is the sum of squares, and the products have gone out; *i.e.*, out of the infinite number of distributions of magnetic force which have the same curl (in amount $4\pi C_1$), the real distribution is that one which makes the energy an absolute minimum.

There are remarkable differences between the two fields of force signified by B_1 and B_2. B_1 has no convergence anywhere; that is its fundamental property. Its lines of force are all closed curves. It necessarily has curl somewhere. Quite apart from our having specified B_1 to have curl, we may show that if it have no convergence it must have curl. For, if the integral of B_1 be taken once round a closed line of force, thus always going with the force, or always against it, and its amount, necessarily differing from zero, be noted, and then we do the same for another closed line of force close to but within the first, the amount must be the same or different. If different, there is evidently curl in the space passed over in transferring one line of force to the other, and we need proceed no further. If the same, there is no curl on the whole. If so, we may go on to a third line of force within the second, and so on till we either find the integral change its value, or in the extreme case find ourselves reduced to a curve bounding an infinitely small area, with the same finite value of the integral, so that we have infinite density of curl. In electro-magnetism, the curl corresponds to $4\pi \times$ current density, so that the existence of closed lines

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of force involves the existence of current somewhere, in fact passing through the closed lines.

Now consider B_2. It must have no curl anywhere. Describe any closed curve in the field. It cannot be made to coincide with a single line of force, for that would give curl at once. The integral of B_2 must be *nil*. Hence, since there is not a single closed line of force in the field, every line of force has a beginning and an end, and the system may be completely divided into tubes which are all terminated, or unclosed, or open. (In order to exclude getting infinite values for the energy, it should be understood that B_1 and B_2 vanish at infinity. And in the case of unclosed lines of force going out to infinity, we may terminate them upon an imaginary large surface enclosing the practical field of force.)

The field B_2 corresponds to that of a permanent magnet on the theory of magnetic matter, or north and south magnetism. This theory gives but an imperfect view of the force of a magnet, but just answers our purpose here. In a bar magnet uniformly magnetised there is positive magnetism at one end and negative at the other; and, in general, there may with irregular magnetisation be both surface and internal distributions of magnetism. The lines of force go from the positive to the negative magnetism always, and are thus all terminated or unclosed. The line integral of force round any close curve is always *nil*. The amount of magnetism anywhere is measured by the amount of convergence or divergence of the force, which convergence and divergence really constitute all the evidence there is of the existence of the matter.

Now, we may arrange our magnetism anyhow, the only restriction being that there is just as much positive as negative, which, interpreted, means that a line which is not closed on itself must have two ends (which nobody can deny); hence we can produce a field of force B_2 which is quite arbitrary, save the restriction that B_2 has no curl anywhere. And since we can arrange electric currents any how with the sole restriction that any line of current must have no ends, or be closed, we can produce another field of force B_1, which is arbitrary subject to B_1 having no convergence. Now superimpose the two fields, the currents and the magnets adding their forces. The result is an unconditionally arbitrary field of force, which has both curl and convergence.

Given, then, an arbitrary field B of unknown source, we may immediately divide it into two fields—one due to current, the other to magnetism. There is only one way of effecting the division, and no third course. For, measure the curl of B everywhere and construct the field, say B_1, which has just that curl and no convergence. Deduct the field B_1 from the field B, the residual field, say B_2, has obviously no curl, and has, therefore, convergence. Or we may start by finding the convergence of B_1, and construct the field, which has the same convergence but no curl; this will be the same B_2 as before, and, deducting it from B, will leave a field B_1, which has no convergence, and which, therefore, has curl. B_1 is due to current, B_2 to magnetism.

Now, the arbitrary field B might be divided into two fields in any number of ways, and in general equation (1) above would hold, it being, however, now permissible for both B_1 and B_2 to have curl and convergence as well as B, and T_{12} would not vanish. But of all these ways there is just one that makes T_{12} vanish, and when that is got there is a perfect separation of the closed from the unclosed tubes of force, the curl is confined to B_1 and the convergence to B_2. [These properties do not belong to magnetic force only, but apply to any continuous vector functions, displacements, velocities, &c., and have extensive applications in physics.] The work spent against magnetic force in carrying a unit pole from A to Z in the field B_2 is independent of the path followed, therefore depending only on the positions of A and Z, and hence we have a scalar-potential. On the other hand, a vector-potential is appropriate to the field B_1, in which the work spent is not independent of the path, although in space not occupied by current a scalar-potential may be used under restrictions. [Compare Theorems II. and III., p. 56 *ante*.]

In proving the minimum property above we applied it to a field of force due to currents. But it is easily seen to apply equally well to a field due to magnetism. Thus, let B_2 be given without curl, representing the field of a magnet, and consider how the quantity ΣB_2^2 is affected by altering the field in any way that does not introduce fresh magnetism. The auxiliary field B_1 must have no convergence, hence $\Sigma \overline{B_1 B_2} = 0$, and ΣB_2^2 becomes $\Sigma B_2^2 + \Sigma B_1^2$, and is, therefore, always increased. Hence ΣB_2^2 for the magnet is the least possible.

An application of the minimum property is to prove that one, and only one, solution exists for the magnetic force or the vector-potential when the current is given (or similarly for the force or scalar-potential when magnetism is given). Merely to illustrate the general course of argument take the case of a given system of current. Prove that there is one, and only one, distribution of magnetic force. Here we define magnetic force so that its curl shall be $4\pi \times$ current, and that it shall be without convergence. Assume that B_1 is a solution. We can show that, if we alter the magnetic force without altering the current, we always increase the quantity ΣB_1^2, and that ΣB_1^2 is, therefore, the least possible. That is to say, if B_1 is a solution, then ΣB_1^2 is a minimum. But ΣB_1^2, being always positive, is capable of being made a minimum, hence there must be a solution. That there is only one follows obviously by assuming there to be another, and showing that it is the same as the first.

It may be asked, and very naturally, what is the use of this when we know there is a solution, and have been working with it all along? Not much, certainly, in the present case. But when we are considering induced magnetisation and various other questions, the equations and conditions to be satisfied may become so complex that it may not be at all evident *à priori* that they are consistent with the existence of a single distribution of force, &c., free from ambiguity and impossibility. In such cases valuable evidence is obtainable by forming the expressions for the energy or analogous quantities, and investigating their minimum or maximum properties.

Consider next the mutual energy of two systems of current. Denoting these densities by C_1 and C_2 respectively we have (equation 13, p. 391)

$$T_{12} = \frac{1}{4\pi} \Sigma \overline{B_1 B_2} = \Sigma \overline{A_1 C_2} = \Sigma \overline{A_2 C_1}.$$

Now here C_1 is the current corresponding to the magnetic force B_1, and C_2 to B_2, and similarly for the vector-potentials. But since all alike have the property of absence of convergence we may equally well let C_1, C_2, A_1, A_2 stand for magnetic force. We have then six fields of force, all different, though related three and three, and we may arrange them in three pairs, so that their mutual energies are equal. As an example, if two coils of any form containing currents be so placed that either current sends no force on the whole through the other, the same will be true of another pair of currents so arranged that the magnetic force of one is represented by the current in one of the original circuits, and the force of the other by the vector-potential of the second of the original currents, and similarly the other pair of currents may be found.

Nor need we stop here, for we may do the same with the newly-obtained systems of magnetic force, and hence construct an unlimited number of pairs of fields which shall have the same mutual energy as a given pair. This may be symbolised thus:—Let B_1, B_2, B_3, B_4, B_5 be fields of force so related that $B_2 = \text{curl } B_1$, $B_3 = \text{curl } B_2$, and so on; and, similarly, let there be another set, with accents, similarly related. Then, for example, starting with B_3 and B'_3, we have, out of other combinations,

$\Sigma \overline{B_3 B'_3} = \Sigma \overline{B_2 B'_4} = \Sigma \overline{B_1 B'_5}$, and also $= \Sigma \overline{B_4 B'_2} = \Sigma \overline{B_5 B'_1}$, the summations extending in each case over the proper fields. We may have, however, merely superficial distributions to deal with.

To wind up the present article, there is a curious form in which the energy may be expressed, which I have not seen noticed, viz., in terms of the vector-potential of current and the scalar-potential of free electricity. Let a steady current be set up, say by a battery, so that we may locate the im-

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pressed E.M.F.'s distinctly at a certain section or sections of the circuit; let the conductivity c be uniform, P the electrostatic, and A the vector-potential, then $T = \frac{c}{2} \Sigma PA_n$, where A_n denotes the normal component of A reckoned inwards, and the summation extends over the whole bounding surface of the circuit. This may be verified by Theorem I. relating to convergence (p. 55 *ante*); P being scalar, PA is a vector, and its surface-integral may be expressed in terms of its convergence within the enclosed space.

Since the potential P is discontinuous at the section of E.M.F. (one, for simplicity), we must cut the circuit there, thus producing an enclosed space which does not enter into itself as the closed conductor does, and reckon P differently for the two new surfaces formed, the values, of course, differing by an amount equal to the E.M.F.

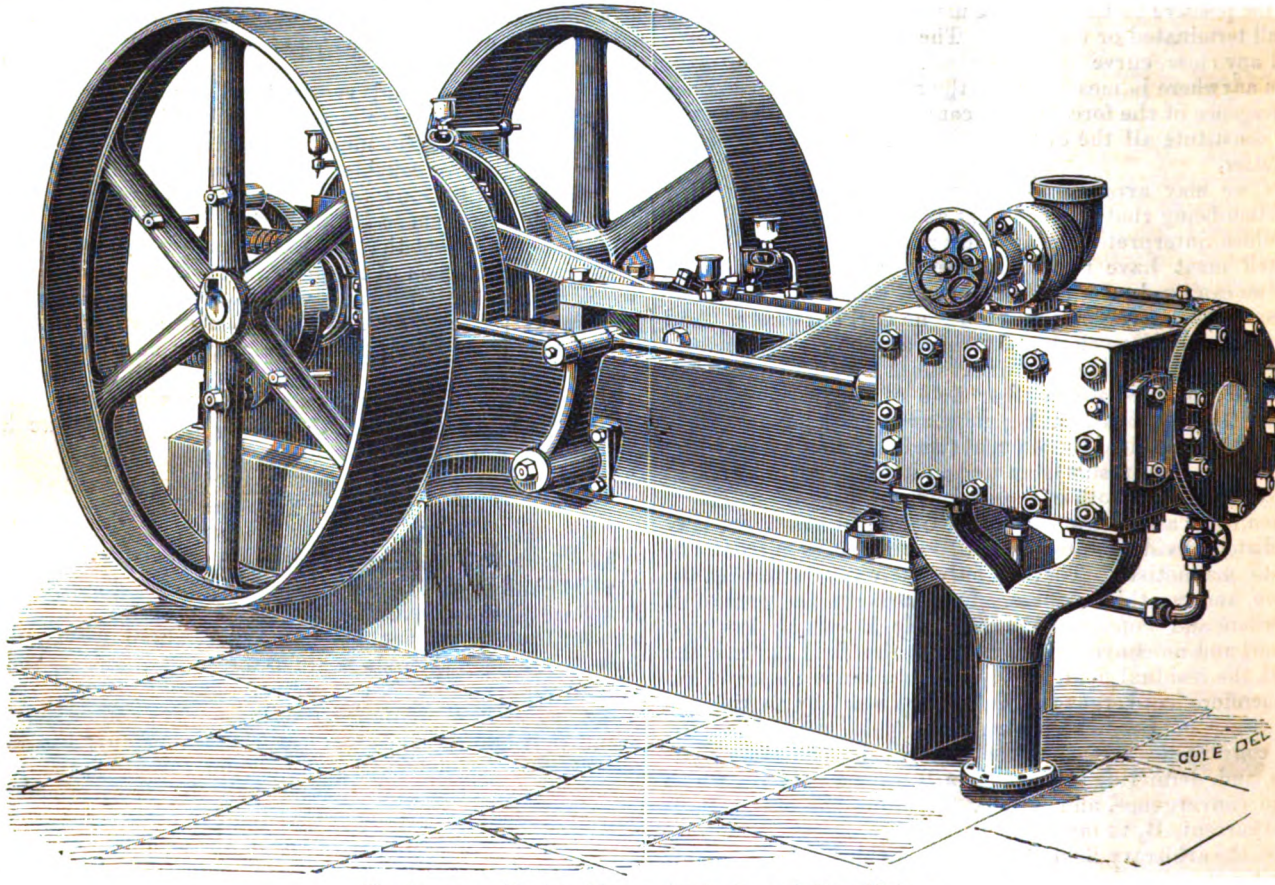
In general, with conductivity not uniform,

$$T = \frac{1}{2}\iint cPA_n dS + \frac{1}{2}\iiint P\,\overline{A\nabla c}\,dV$$

where dS and dV are elements of surface and of volume, and ∇c is the vector rate of increase of c.

EDISON'S SYSTEM AT WATERLOO STATION AND THE HOUSES OF PARLIAMENT.

There is no doubt that the Edison installation at Waterloo Station is one of the best examples of electric lighting in England. The fact that the details of this system have been so carefully studied, and have been designed each to fulfil its exact duties makes the system one that always deserves the most careful investigation. We find that, although so much attention has already been given to details, there is still the closest supervision, and improvements are being constantly made. This is as it should be; theoretically a design may seem complete, but the experience gained by practice is sure to suggest modifications. We do not know that there is anything new to chronicle as regards the lamps, which are here of the ordinary A type; but in these installations a new steam motor has been used. So far as we know, only four of these engines are being used as yet in connection with the electric light in England—one at Waterloo, one at the Houses of Parliament, one at Messrs. Mather and Platt's, of Manchester, and one at the Holborn Viaduct Central Station. These engines are the Lawrence engines, as constructed by Messrs. Armington and Sims's Company, Providence, Rhode Island, U.S.A. The builders of these engines claim for them extreme simplicity, the absence of parts requiring frequent adjustment, great regularity of speed, small space required for engine and fly-wheel, and consequent rigidity in stationary and moving parts, the use of short and nearly parallel belts, and large bearings. The automatic cut-off regulator used is said to be original, and perfect in its operations. It is attached directly to the valve-rod, and varies the point of cut-off as the resistance requires from the commencement to seven-tenths of the stroke without changing the lead. It acts very quickly, and whatever the change in load or pressure of steam, the speed remains practically constant. The variation of speed from an extreme light load to the capacity of the engine does not exceed two per cent. The valve is perfectly balanced, and at all times surrounded by live steam. By its construction it permits full boiler pressure to be maintained in the cylinder up to the point of cut off. The engines are built of various types, from 19 h.-p. indicated non-condensing single engines to 236 h.-p., and double engines from 184 to 472 h.-p. The report of the Edison Company is extremely favourable to these engines. We give a view of one of them, also two views of the governor. The valve has no packing rings, but is a tube enlarged at each



The Lawrence Engine: Messrs. Armington and Sims, Makers.

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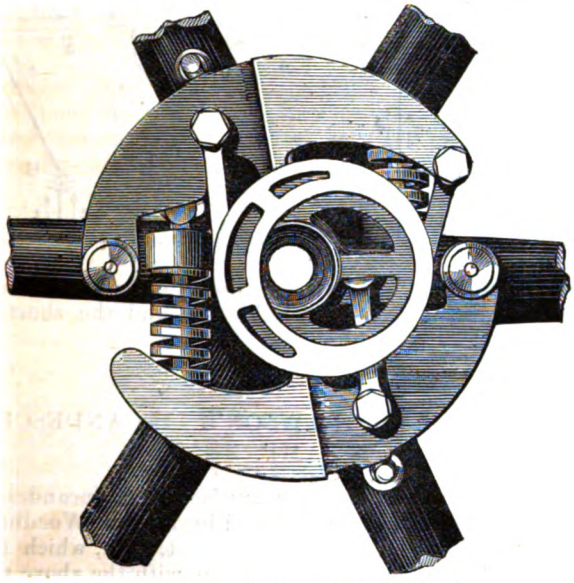
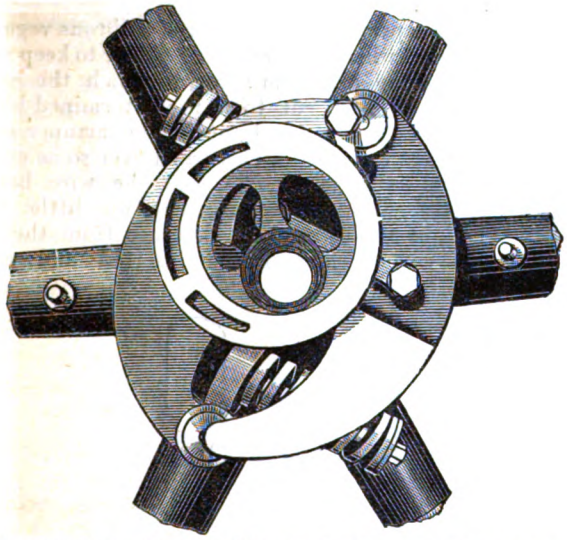
end, and after being turned and having the steam edges finished, is ground to size with a lead lap. Steam is taken around the outer middle part of the valve, which is thus in equilibrium, the exhaust taking place over the ends and into a Y branch pipe that is led vertically downwards. Small bonnets at each end of the valve chest enable the valve to be got at without removing the main cover. The valve in the 125 horse-power engine is $5\frac{1}{4}$in. diameter, and having double admission opening, gives a port opening equivalent to 30in. long by $2\frac{1}{8}$in. in width. The working travel of this size would be 3in., with an extreme of $5\frac{3}{8}$in. The valve motion is so arranged that the steam admission can be varied by the governor from the lead of 1-32in. to the $\frac{5}{8}$th of the stroke. The piston is made very light, and has two rings. The cross-head is of cast iron, with gibs at bottom, which are to be set out with liners as wear takes place. The crosshead pin is of steel, running through a steel bush flattened top and bottom. One fault, if fault it may be called, of this engine is in the difficulty of obtaining access to the steel pin. The shaft is of "gun iron" or air furnace cast iron, and the disc is shrunk upon it before finally being trued up.



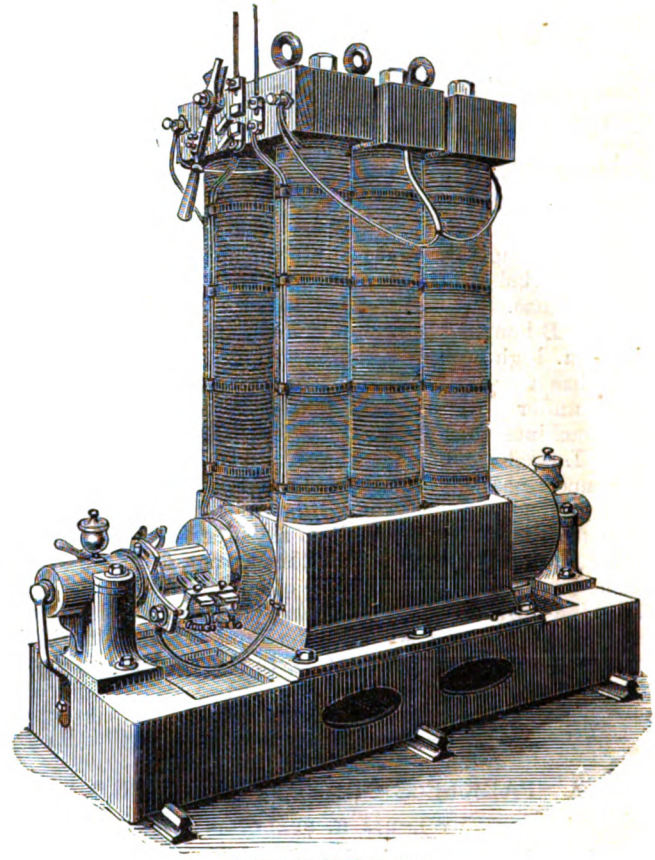
Governor to Armington and Sims's Engine.



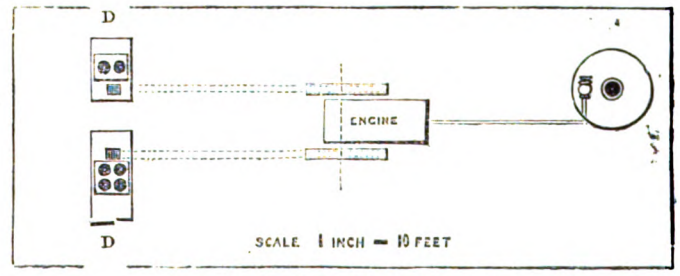
Governor to Armington and Sims's Engine.—Another position.

The governing arrangements consist of two excentrics on the main shafts, each of which is movable and controlled by the action of two suspended weights contained in a drum. These parts are all carried on the main shaft, the excentrics being movable on the shaft itself, and the weight carried on a pin going through a hole by the regulator drum. When the weight is by the rotation thrown outwards it carries by means of a link the outer excentric in one direction, but the inner excentric is by the outward motion of the opposite weight carried in the opposite direction. Thus the one excentric changes the throw and the other the real centre of the combined or double excentric. Another weight on the opposite side is used merely for balance, and is fastened to the inner excentric. The returning or balancing springs are arranged to be always in compression, being seated upon a small bracket through which a rod passes and takes hold of a cap on the opposite end.

The lubricating arrangements are worked out with considerable care, as is necessary in high-speed engines, their success in continuous running depending largely upon this detail. The supply of oil may be regulated by merely screwing up or down the cover and inserting fresh oil through the small hole in the cover. A Siebert sight-feed lubricator is used on the steam pipe. A horizontal pipe is brought from the main steam pipe outwards, then fitted with a cock, and turned down. In this unprotected pipe the steam condenses, and the water column thus formed is admitted by a valve to the under side of a cup filled with oil, the only escape being at the top through a central vertical pipe leading to the gauge glass which communicates by a pipe and valve with a lower part of the main steam pipe. The gauge glass being also filled with "condense water," the oil passes from the small interior pipe with a velocity due to the head



Edison's K Dynamo.



Arrangement of Machines at Waterloo.

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of water up through the water in the gauge glass, being readily seen in doing so, and being capable of all ranges of regulation, from a steady stream to one drop in three minutes.

At these installations Edison Z, L, and K dynamos are used. The Z dynamo is intended to produce a current for 60 A (16 candle-power) or 120 B (8 candle-power) lamps. It occupies a floor space of 45in. by 39in., has a height of 6ft., weighs 3,000lb., and makes 1,200 revolutions per minute, with a pulley of 6in. face and 10in. diameter. It is reckoned that this machine requires about 10 horse-power. The first Z dynamo was fixed September 28, 1881, in the mill of Mr. James Harrison, Newburgh, N.Y., and up to September 1, 1882, some seventy installations of similar machines were made. The L dynamo is intended to generate a current for 150 A or 300 B lamps. It occupies a floor space 60in. by 39in., has a height of 6ft. 6in., weighs 6,000lb., and uses about 19 horse-power at the normal speed of 900 revolutions per minute. The first L dynamo was sent out from the works on August 4, 1882. To look at, the L machine is a double Z, while the K machine is a treble Z, that is, while the Z dynamo has one electro-magnet, the L has two, and the K three. The K dynamo, illustrated on p. 441, is somewhat new to this country. Machines of this type were exhibited at the late Munich Exhibition, as will be seen on reference to our report. Although the first of this type of machines did not leave the workshops till June 3, 1882, a number of them are already in use. It is intended to supply current for 250 A or 500 B lamps. It occupies floor space 70in. by 39in., is 6ft. 6in. high, weighs 8,250lb., makes 900 revolutions per minute, has a pulley with 9in. face and 14in. diameter, and requires under normal conditions 35 horse-power.

The machines used at the Waterloo installation are one Z and one L machine, arranged as shown in the plan on p. 441. Two K machines will be used for the work at the Houses of Parliament. One K machine will be sufficient to generate the current for the lamps, but the two machines will usually run together, each supplying one-half the current, except in case of accident to one machine, when the other would be called upon to do all the work. Great care is being taken to provide against every emergency, and we have no doubt the result will be complete success. We shall return to this subject again, and illustrate the fittings to be used.

A SPARKLESS CURRENT-BREAKER.*

BY LOUIS H. SPELLIER.

The fact that the spark of the induced current of electro-magnetic instruments will destroy the contact surfaces by which the making and breaking of the circuit is effected is very keenly felt on current-breakers for electro-magnetic time telegraphs.

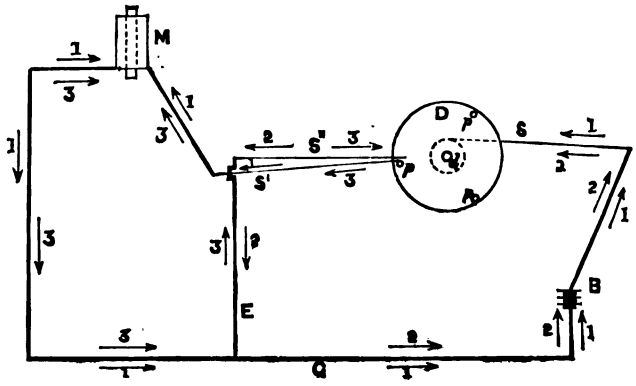
A device for the purpose of obviating the spark, invented by Dr. Hipp, has been in use successfully for some years at Geneva, to distribute astronomical time through the different sections of that city.

The writer presents in the accompanying diagram a device of his own for the same purpose, which, he believes, will commend itself for simplicity as well as for effectiveness.

With the exception of an additional contact spring, S″, the current-breaker is the same as described in the *Journal of the Franklin Institute*, August number, 1882.

The metal disc D is fastened to the axle of the escape-wheel of a clock, and has as many platinum pins, *p*, attached vertically upon its face, as there are openings and closings of the circuit needed during the time it completes one revolution. *d* is a platinum disc, fastened to the pin-bearing disc; S and S′ are two contact springs. The spring S rests upon the platinum disc, while S′ is to make the contact with the pins *p*. When the disc moves with the escape-wheel of the clock, and the spring S′ comes in contact with one of the pins, *p*, the circuit of the battery is completed, and broken when removed from it.

In the diagram D represents the current-breaker, B the battery, M the electro-magnet, and G the ground conductor. The spring S′ is in contact with a pin, and thereby completes the circuit. The current now takes the course as shown by the arrows 1. The contact spring S″ is placed a little higher than S′, and, therefore, does not yet touch the pin *p*. But, as soon as D moves on again, S″ will, a moment before S′ leaves the pin, come also in contact with it; at this moment S″ will make a short circuit through the conductor E, and the course of the battery current becomes that of the arrows 2, while the induced current of M, at the moment the short



circuit is made, takes the course as indicated by the arrows 3. A moment after S′ leaves *p*, S″ follows it, and the short circuit of the battery is also broken.

* From the *Journal of the Franklin Institute* for March, 1883.

WOODHOUSE AND RAWSON'S INCANDESCENT LAMP.

Certain modifications in the manufacture of incandescent lamps have recently been introduced by Messrs. Woodhouse and Rawson, of 11, Queen Victoria-street, E.C., which have resulted in the production of a lamp with the above title. With the help of our illustrations and a short description we think our readers will readily grasp the details of its manufacture.

The filaments are prepared from stuff of a fibrous vegetable nature, by processes which the inventors prefer to keep secret for the present. The platinum wires, to which the carbon filament is affixed, are first cut to a pre-determined length, after which the ends are flattened out in the manner shown in Fig. 1 (A); these ends are then turned over so as each to form a small tube as in Fig. 1 (B), and the wire bent to the shape shown, the ends next the two little tubes being bent at right angles a short distance from the tube. After this the carbon filament is inserted and firmly

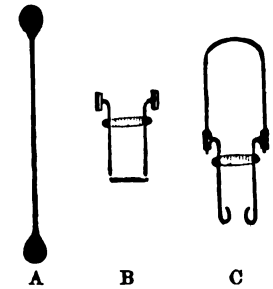


FIG. 1.—Showing the Method of Attaching the Filament to the Platinum Wires.

fixed in its place by cement, Fig. 1 (C). A glass yoke is fused on to both platinum wires as a stay, by means of which to hold them when they are cut at the bottom and their ends looped up, as shown in the above figures. The whole, wires and filament, is then inserted in the glass globe through the neck, held in its proper place, and the neck sealed. It only remains for the globe to be exhausted; this is done through the top, and the globe finally sealed, when the lamp has the appearance shown in Fig. 2.

The complete lamp is then placed on a circuit, run for a certain length of time, and the E.M.F. required for it ascertained and marked on the globe.

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The processes of manufacture are consecutive, and are almost all performed by girls, who are preferred by the makers as being cheaper, and having better eyes and more delicate hands for the work than men. By the side of the lamp we show (Fig. 2) a form of holder patented by the makers. As will be seen, good contact is ensured by the spiral springs, which tend to keep the platinum hooks always in firm contact with the former. The three brass prongs have sufficient spring in them to grasp the body of the lamp tight and keep it steady, whilst they do not put too much strain on the platinum wires. The holder can be adapted to ordinary gas-fittings. Our illustration shows it screwed into a wall bracket. We may mention that the lamp illustrated above is of 20 candle-power, and is made to work with from 10 to 100 volts; from experience, however, it has been found that these lamps when constructed to work with from 40 to 50 volts are found to be the most satisfactory.

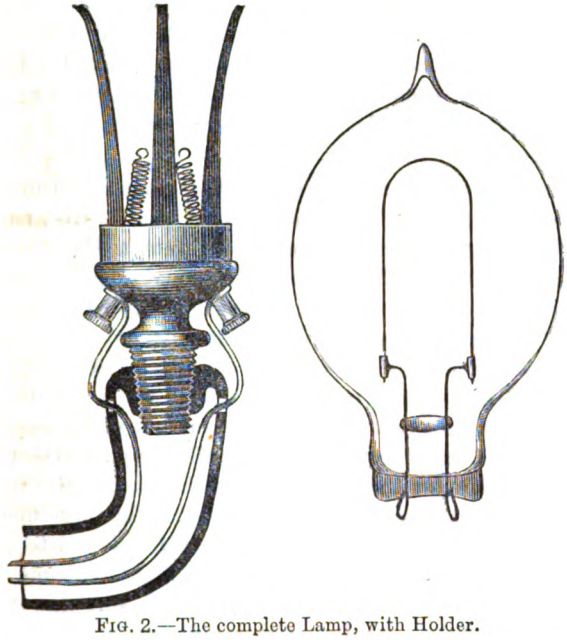

Fig. 2.—The complete Lamp, with Holder.

Another form of the above lamp is fitted with a brass collar filled with cement. In this lamp the platinum wires are left straight, and have copper ones soldered on to them; these latter project beyond the cement in the shape of hooks. The object of the brass collar and cement is to strengthen the neck of the lamp and add to its appearance. The makers find that our Continental friends prefer this shape.

In Fig. 3 is shown a full size engraving of a little lamp of one candle-power, made for surgical purposes. The makers turn out one rather larger than the above of three candle-

Fig. 3.—Lamp for Surgical purposes (full size).

power, for theatrical use, which is coloured by a special process, by means of which all blistering from heat is avoided. They also make lamps specially with the view to their use with batteries the resistance of which is kept low, so that they can be run with an E.M.F. of three to four volts. We may add that Messrs. Woodhouse and Rawson do not confine themselves to the manufacture of their own lamps, but have for some time past been, and are now, engaged in manufacturing and experimenting for the patentees of other lamps. Specimens of these lamps can be seen, amongst other places, at the Westminster Aquarium, where they are being used by Messrs. Goulard and Gibbs, the exhibitors of a new system of current regulation. Some coloured lamps will also be found in the goldfish tank.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

The solutions in this number are solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. Rimington, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

17. What is meant by the "efficiency of an electromotor?" Explain in detail, and give sketches of the method you would employ to measure this efficiency. Give the results that have been obtained with magneto and dynamo machines used as motors.

Ans. The electrical efficiency of an electromotor is the ratio between the power put electrically into the motor and the useful portion of this power which appears as mechanical work. The efficiency of a motor, however, does not depend entirely on itself, but also on the back E.M.F. it generates in rotating as related to the E.M.F. of the generator. The nearer the former approaches the latter the greater the percentage of power given out by the motor with relation to that put into the generator.

To measure the efficiency of a motor, take the E.M.F. at the terminals, and the current passing through it, then, if f be this efficiency, $f = \frac{e - C\rho}{e}$, where e = E.M.F. at terminals, C = current and ρ = internal resistance of the motor when at rest, for $f = \frac{E}{e}$ and $E = e - C\rho$, where E is the E.M.F. in the coils of the motor.

M. Marcel Deprez recently transmitted power from Miesbach to Munich, a distance of over 34 miles, through a double line of telegraph wire. He employed two similar Gramme dynamos, wound with high-resistance coils. The resistance of each machine was 470 ohms, while the line was 950. The speed of the generator was 2,100 revolutions, that of the motor 1,400. The E.M.F. of the generator at terminals = 2,400 volts, that of motor = 1,600. The mechanical efficiency was said to be about 32 per cent.

18. In what case would you recommend the employment of water transmission, and in what cases electrical transmission of power?

Ans. Transmission of power by water may be effected economically when a low speed and high pressure are required over short distances. The viscosity of water being very great, a great deal of power is wasted by the friction of the water on itself, and much more at low pressures with a large quantity flowing than at high pressure with a small quantity.

The electric transmission of power can be best employed when a high speed is required over long distances. The longer the distance the power is to be transmitted, the higher should be the E.M.F. of the generator and the back E.M.F. of the motor.

19. Describe, with sketches, the methods in detail of using a secondary battery to make an electric light independent of fluctuations in the speed of a dynamo—first, when the generator is a "series dynamo;" second, when it is a "shunt dynamo."

Ans. When the dynamo is a shunt one the accumulators, arranged in series so as to have the same E.M.F. that is desired to be maintained between the positive and negative leads, are generally employed as a shunt on the external circuit.

When the dynamo is a series one the batteries can be employed in the same manner, but an automatic cut out should be placed in the circuit between them and the dynamo, so that if the E.M.F. at the terminals of the dynamo falls below that at the terminals of the batteries, through great decrease in the speed of the engine or any other cause, the battery circuit is instantly broken. If this precaution be not taken, and the batteries should begin to discharge through the dynamo, its polarity will be reversed, and the combined strength of the current from the machine and the accumulators would probably burn up the former. In the case of the shunt dynamo, however, the current from the batteries, if they happened to discharge through the machine, would not reverse its polarity, as the current would flow in the same direction round the field-magnets as when the machine was exciting them.

Another disadvantage consequent on using a series dynamo in combination with accumulators is that the latter cannot be put on until the dynamo has been run through some resistance to enable it to get up sufficient E.M.F. to overcome that of the accumulators.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

SUBSCRIBER.—*Eligibility consists in approval of the Council and the members. Any gentleman desirous of admission obtains a nomination form from the Secretary,* 4, *Broad Sanctuary, and the necessary signatures. The gentlemen who sign the form are really sponsors, and a grave responsibility rests upon them. The nomination is submitted to the Council, approved or rejected. The members signify their approval of the Council's action by ballot at an ordinary meeting.*

ELECTRIC.—*Similar suggestions to yours have been frequently put forward in these columns both by correspondents and ourselves.* (1) *No doubt more light would be almost, if not quite, as beneficial as more police.* (2) *Your suggestion as to an arc light for steamers has been advocated over and over again since the disasters you mention, but nobody seems to have taken it up yet.*

C. E. M. (BUCKHURST HILL).—(1) *Do not use two contact breakers.* (2) *It is against our rule to give prices. Write to the makers* (see CORRESPONDENCE, *p.* 446). *For wire the prices differ considerably. Write to Messrs. Elliott Brothers, or Messrs. Clark, Muirhead, and Co., or Messrs. Johnston Brothers, or Messrs. Glover. These firms will serve you well, and especially so if large quantities of wire are wanted.*

H. MEIER (CALAIS).—*It is very probable that we shall give a description of the small portable battery you mention. The lecture referred to will not, we think, be published more fully than we have given it. We do not think of republishing the articles. Sir F. Bramwell's address is* 37, *Great George-street, London, S.W.*

D. M. (A YOUNG ELECTRICIAN).—*We cannot publish any fuller report of the lecture you mention than that given in our last issue. For the date on which the lecture is to be redelivered and any other particulars you had better write to the secretary of the Institute, South Grove, Highgate.*

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THE CITY AND GUILDS OF LONDON INSTITUTE.

The report to the governors of the above institute for the year 1882, presented at their meeting on the 14th inst., is now before us, and it would hardly be possible to overstate the encouragement it will afford to all persons interested in the promotion of technical education. From the very first, the movement inaugurated by the City of London and its ancient guilds has been an assured success. True, the character of the instruction and the results of the examinations have been, and will continue to be for a long while yet to come, subjects of criticism; and quite legitimately so, for it is only by the lessons of experience, and the sharp eyes of lookers-on that such schemes can be moulded into perfect working order. Pending the completion of the Finsbury Institute, and again that of the central building at Kensington, the work must necessarily be carried forward on tentative lines; but the experience gained in the interval will enable the managers to cope with the then vastly increased area of education in a manner they could not have done had it come upon them quite suddenly and unprepared. As it is, the growth of the movement has been abnormal, and already is ahead of the teaching power at its command. The lack of competent teachers is, in fact, the chief difficulty at present to be contended against; but this is a want which the colleges themselves may be trusted to supply in due time.

The one great trouble which besets most institutes, and and on which some of them are, indeed, said to live, namely, financial embarrassment, does not threaten the City and Guilds Institute at all. It makes the usual appeals for material support, as a matter of course; but, unlike its companions above referred to, it can subsist very comfortably without those periodical spasms of vitality which poor people are compelled to suffer in order to enlist the sympathies of the rich. In the short space of three or four years something over £100,000 has been raised for building purposes alone; and the income for the past year, which reached the sum of £25,000, appears likely to be maintained. The mere mention of such figures is enough to drive the doers of non-technical good works to despair; perhaps, also, it may have some effect in disarming envious critics of the political sort who "want to know" what the City does with its money.

With such an income as this, and with the material support of the wealthy Livery Companies of the metropolis, almost all of whom have now given in their adhesion to the enterprise, there is every prospect of carrying out the work of technical education on a thorough and extensive scale. By scholarships granted to metropolitan schools or colleges, and by donations to provincial institutes, the liberality of the patrons is already finding useful outlets, and the munificent manner in which the central establishments are being fitted up affords proof that whatever money can do will be done. The importance of assisting affiliated schools is already recognised by the board, who express a hope that they may be able to support, in various parts of London and in the suburbs near to the houses of the workmen, classes in which technical instruction of a scientific kind, similar to that obtainable at the Finsbury College, may be established. It is stated that large additional funds will be required before we can place the British workman, in respect to facilities for technical instruction, on a level with his fellow workmen on the Continent. For our part, we should be inclined to suspect that the existing difference is rather in the men than in the facilities; but if it be true that money, and money only, will remove the difference, we have no apprehension as to its not being forthcoming when wanted.

One other difficulty as regards employers of artisans is referred to in the report, and is closely related to that just alluded to in respect to the men themselves. It is still a matter of regret, writes one of the hon. secretaries of the institute, that large employers of labour do not encourage

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their *employés* to the same extent as is the case on the Continent to attend evening science and technical classes, and the committee feel that, without the co-operation of the manufacturers, technical classes cannot be attended as regularly nor as numerously as is to be desired. It is to be regretted that this appeal and the grounds on which it is made cannot be brought home to the understandings of employers. Still the attendances are steadily increasing, the students now attached to the several registered classes of the institute numbering over 4,000 persons, whilst at the London Institute alone there are 500. In proof of the growing interest taken in the subject, the Associated Chambers of Commerce only the other day adopted a resolution recommending that steps be taken as far as possible to provide technical instruction in the trades of the localities where any of its affiliated chambers exist, and suggesting that each such chamber should nominate a committee to promote the movement.

We are glad to notice in this relation that the City and Guilds Institute in London has set the example of teaching apprentices at reduced terms—apprenticeship standing in need of all the help and encouragement such institutes are able to afford. Many people think that the bad repute into which apprenticeship has fallen in this country has something to do with the backwardness of our skilled artisans, compared with those of such countries as Germany and France. Dr. Siemens's remarks on this head at the distribution of prizes in December last, a full account of which is appended to the present report, are well deserving of attention. We cannot, perhaps, revert to the system of the Middle Ages, nor revive those powers of the guilds which they lost only in quite recent times. But we may do much to elevate art and manufacture to a higher and nobler level, and to teach both master and man to be proud of their calling—too proud of it to permit competition prices to rule, on the one hand, against honest productions, or, on the other, to regard tenpence an hour as the sole aim and object of producing. To these ends the system of technical education of which the City and Guilds Institute is the chief centre will largely contribute, by supplying that fundamental knowledge without which all handicraft is liable to become mechanical, unprogressive, and slipshod.

CORRESPONDENCE.

PORTABLE LAMP.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I beg to inform "One in the Dark" that such an apparatus as he requires could be made, but it would be on a much larger scale than the one given by Mr. C. J. Clark. He would require an incandescent lamp of the platinum type, with a filament of very low resistance, and a portable bichromate battery. The plates could be arranged as those in an accumulator, with a small space between them to allow the liquid to circulate freely. A battery containing six carbon plates 4 × 3 × ¼in., and five zinc plates 4 × 3 × 1-32in. in a solution of bichromate of potash two ounces, sulphuric acid one ounce, water 12 ounces. This would bring to incandescence a piece of platinum wire 1in. long, No. 36 gauge, and give "One in the Dark" sufficient light to read his music by. The time this battery would remain in action depends upon the amount of solution in the cell. The plates would require a space of 4 × 3 × 2in. The size of the outer cell would be determined by himself; the larger it is the longer the lamp will burn. He could carry this in his hand or in his pocket. Trusting this is sufficient.—Yours, &c.,

R. BOWMAN.

Cadby's Steam Works, Leather-lane, E.C.

PLATINISING CARBONS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should be glad if you or one of the readers of your interesting journal could explain how it is that a greater lighting power, combined with less resistance, is obtained by platinising the filament of an incandescent lamp. I understand that Zanni platinises a filament, and in some cases deposits an outer coating of carbon, thereby obtaining the above-mentioned advantages.—Yours, &c.,

AN INQUIRER.

THE TELEPHONE CASE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I entertain the opinion that one very important point was apparently overlooked in the telephone case, which is this, that the production of audible sounds, or rather (as I think the judgment calls them) articulate sounds, is not a *manufacture*, and therefore not the subject of a patent; and the great difficulty is to determine how far the production of that class of sounds is due to electricity, and how far to the invention. One crucial test as to the validity of the patent is this—does or does it not claim the manufacture of instruments similar to that exhibited at Glasgow? The point relied on by the Court to show that the patent was not anticipated by that disclosure, namely, that it could not at that time be worked because the then state of knowledge was not sufficient to enable people to do so—although it can now be used for that purpose—appears to me to involve this, that the patentee can claim the use of subsequent discoveries not made by himself, which is inconsistent with the Act limiting monopolies to the true and first inventor. I think both the owners of that patent, as well as many other patentees, forget the rule that, though you can have a valid patent for applying a new contrivance to an old object, yet you cannot have a patent for applying an old contrivance to a new object. As a quaint old judge put it, "If all mankind had been accustomed to eat soup with a spoon you could not have a patent for eating peas with a spoon." Electricity belongs to all mankind, and the use of it cannot be monopolised. If Graham Bell's invention is *essential* to the result, then, by confining himself to his invention, he will secure the monopoly; but the patent will not be valid if he claims more than the instrument that he has actually invented, or colourable evasions of it. "If the whole is not new it is hanging terrors over them," said the judge in one case which, I think, has never been disputed.—Yours, &c.,

J. A. S.

THE SOCIETY OF TELEGRAPH ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The Society of Telegraph Engineers was started in 1871, and soon attained a position in the scientific world which gave promise of an ever-increasing reputation with increasing years. This early promise was, however, not long fulfilled, and a few years ago the friends of the young institution had to see that, far from bettering, or even maintaining, its ground as a scientific body, it seemed to be steadily subsiding into an assemblage of telegraphists and telegraph engineers. Although the domain of electricity was daily becoming more and more extensive, we, as a body, seemed to be contracting our sphere of usefulness within that small portion of it represented by the requirements of electric telegraphy (used in its widest sense), leaving the rest of the field almost, if not entirely, untouched.

Under these circumstances the large and increasing body of pure electricians and workers in the other hundred and one applications of electricity, feeling that there was no place for

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them in our midst, did not join us as eagerly as could be wished, while of those who did enter our ranks, or have been with us from the first, very few have taken any interest in our proceedings.

It was seen that such a state of things must, in the end, prove fatal to the society, and so, about 1879, its friends proposed to alter its title so as to embrace all classes of labourers in the allied fields of electricity and magnetism. In December, 1880, the new title was proclaimed—the Society of Telegraph Engineers and of Electricians—and it was hoped that, with the new title, we would make a new start, and gather into our net all the wealth of electric and magnetic science.

Judging, however, from the contents of the last two volumes of the *Journal* we find, with regret, that there has been little or no change in this respect. We are still little else than telegraphists, for the great majority of the papers read at our meetings have been by telegraphists on telegraphic subjects. Abstract papers, and, generally, all papers on non-telegraphic subjects are still taken elsewhere, and we frequently see distinguished members of our body—even members of our council—reading papers before the Royal and Physical Societies, the Society of Arts, and the Institutions of Civil and Mechanical Engineers, most, if not all of which, should, in fairness, be given to us.

This is an unpleasant, not to say humiliating, state of things, to which, in all earnestness, I beg to draw the attention of those distinguished members mentioned above, and, generally, all members of the society, reminding them of the old saw—united we stand, divided we fall.—Yours, &c.,

London, March 19, 1883. J. J. Fahie, M.S.T.E. & E.

THE EFFICIENCY OF ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It is of the greatest interest, both to scientific men and to the general public, to know what is the real depreciation which takes place in the efficiency of accumulators. Will not Professor Ayrton or Dr. Gladstone tell the world once for all what is the observed loss of efficiency in a cell that has been in use for, say, 1,000 hours, and in what ratio the loss progresses?

Professor Ayrton showed accumulators in work at the London Institution, and I believe he has had some for a considerable time at the buildings of the City and Guilds of London Institute. He can surely set this question at rest by mentioning the actual loss observed in these specimens.—Yours, &c., I. T.

March 20, 1883.

CLARKE'S PORTABLE BATTERY, GAS LIGHTER, &c.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: I have observed of late several questions in your paper on the subject of my patent electric gas lighters and induction coils and batteries. I beg to inform your correspondents that I have now transferred my inventions to the Electric Portable Battery and Gas Igniting Company (Limited), whose works are at Clegg's Court, Salford, Manchester. I shall be happy to give your correspondents any information they may desire if they will kindly communicate with me direct.—Yours, &c. Charles L. Clarke.

The Electric Portable Battery and Gas Igniting Company (Limited).

GUTTA PERCHA.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Can any of your readers give information as to the cost of gutta percha per pound, in the condition in which it is put upon the conducting wires of cables, also upon the wires laid under town streets? The price of the uncleansed material seems to vary largely, judging from the following items given in the *Public Ledger*:—Gutta percha, good to fine, per lb., 1s. 8d. to 3s. 9d.; low to medium, 3d. to 1s. 7d.

Likewise, can any of your readers give details of the preparation of gutta percha by the Malays? What proportions of scraped bark and cocoa nut oil do they work in? What physical changes does it undergo from the time of leaving the tree until it reaches the hands of the merchant? Do its physical conditions slowly change at all during the first month after the Malays have boiled it?—Yours, &c.,

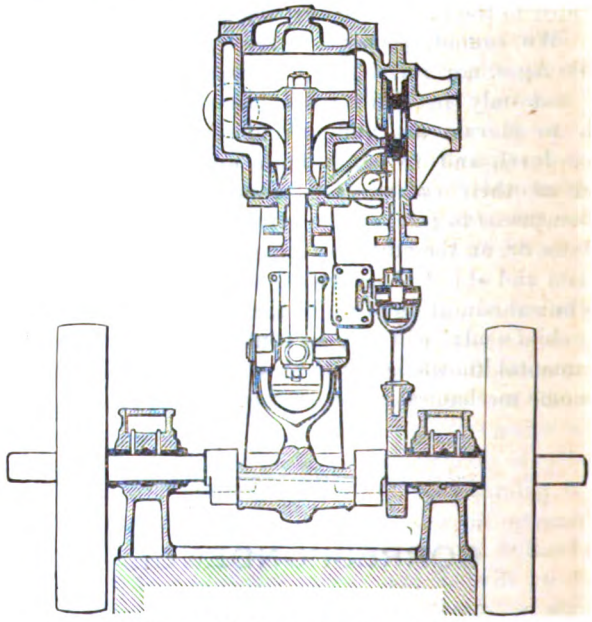
W. H. Harrison.

3, St. Michael's-terrace, Folkestone.

THE FARCOT COMPOUND ENGINE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Six months ago you were good enough to illustrate an economical type of compound engine specially adapted for small installations of the electric light. This engine has already been applied to such purpose with exceedingly good results, and I now find that a design somewhat similar is being adopted in France by the principal lighting companies. I allude to the Farcot high speed compound engine, of which I enclose a sketch, from which it will be seen that although in outward form it is very like the Kingdom engine, illustrated by you, it differs very much in the arrangement of the high and low pressure cylinders. These are cast together in one piece, and communicate one with the other, thus dispensing with the intermediate stuffing box and cylinder cover, the steam, after doing its work in the lower cylinder, being expanded in the upper so as to make the return stroke.



Farcot's Engine for Electric Light.

Another novelty in this engine is the arrangement of the governor, which gives complete control over the speed in a simple manner by means of a weighted hydraulic piston connected to a small centrifugal pump worked from the crank shaft. As the speed increases so does the quantity of water delivered by the pump, and the piston is raised, shutting the throttle valve.

The engine I examined is one of a number ordered by the Société Electrique Gramme, and has given excellent diagrams, which I should be pleased to show to any one interested in such matters.—Yours, &c.,

Paris, March 9. Killingworth Hedges.

SAFE WORKING CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: Your correspondent, "H. B.," who apparently is the compiler of your Supplement No. 2, has worked from a

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formula giving the rise of temperature per second which *would* take place in a wire through which an electric current is flowing *if* the wire lost no heat by radiation, convection, or conduction. We in practice have nothing to do with such hypothetical cases. I gave the true theory of, and the experiments upon, the currents which, in passing through wires of different diameters, produce the same permanent rise of temperature, at the British Association, last year, and in *The Electrician*, last September. I have lately seen some examples correctly worked out in an admirable little book, "Day's Electric Light Arithmetic."—Yours, &c.,

GEORGE FORBES.

34, Great George-street, Westminster,
March 20, 1883.

THE INSTITUTION OF CIVIL ENGINEERS.

The third of the series of six lectures on the applications of electricity was delivered on Thursday evening, the 15th March, by Dr. C. William Siemens, F.R.S., M. Inst. C.E. The subject was "The Electrical Transmission and Storage of Power." The following is an abstract of the lecture :—

Dr. SIEMENS, in opening the discourse, adverted to the object the Council had in view in organising these occasional lectures, which were not to be lectures upon general topics, but the outcome of such special study and practical experience as members of the institution had exceptional opportunities of acquiring in the course of their professional occupation. The subject to be dealt with during the present session was that of electricity. Already telegraphy had been brought forward by Mr. W. H. Preece, and telephonic communication by Sir Frederick Bramwell.

Thus far electricity had been introduced as the swift and subtle agency by which signals were produced either by mechanical means or by the human voice, and flashed almost instantaneously to distances which were limited, with regard to the former, by restrictions imposed by the globe. To Dr. Siemens had been assigned the task of introducing to their notice electric energy in a different aspect. Although still giving evidence of swiftness and precision, the effects he should dwell upon were no longer such as could be perceived only through the most delicate instruments human ingenuity could contrive, but were capable of rivalling the steam engine, compressed air, and the hydraulic accumulator, in the accomplishment of actual work.

In the early attempts at magneto-electric machines, it was shown that, so long as their effect depended upon the oxidation of zinc in a battery, no commercially useful results could have been anticipated. The thermo-battery, the discovery of Seebeck in 1882, was alluded to as a means of converting heat into electric energy in the most direct manner; but this conversion could not be an entire one, because the second law of thermo-dynamics, which prevented the realisation as mechanical force of more that 1-7th part of the heat energy produced in combustion under the boiler, applied equally to the thermo-electric battery, in which the heat, conducted from the hot points of juncture to the cold, constituted a formidable loss. The electromotive force of each thermo-electric element did not exceed 0·036 of a volt, and 1,800 elements were therefore necessary to work an incandescense lamp.

A most useful application of the thermo-electric battery for measuring radiant heat, the thermopile, was exhibited. By means of an ingenious modification of the electrical pyrometer, named the bolometer, valuable researches in measuring solar radiations had been made by Professor Langley.

Faraday's great discovery of magneto-induction was next noticed, and the original instrument by which he had elicited the first electric spark before the members of the Royal Institution in 1831 was shown in operation. It was proved that although the individual current produced by magneto-induction was exceedingly small and momentary in action, it was capable of unlimited multiplication by mechanical arrangements of a simple kind, and that by such multiplication the powerful effects of the dynamo machine of the present day were built up. One of the means for accomplishing such multiplication was the Siemens armature of 1856. Another step of importance was that involved in the Pacinotti ring, known in its practical application as the machine of Gramme. A third step, that of the self-exciting principle, was first communicated by Dr. Werner Siemens to the Berlin Academy, on the 17th January, 1867, and by the lecturer to the Royal Society on the 4th of the following month. This was read on the 14th of February, when the late Sir Charles Wheatstone also brought forward a paper embodying the same principle. The lecturer's machine, which was then exhibited, and which might be looked upon as the first of its kind, was shown in operation; it had done useful work for many years as a means of exciting steel magnets. A suggestion, contained in Sir Charles Wheatstone's Paper, that "a very remarkable increase of all the effects, accompanied by a diminution in the resistance of the machine, is observed when a cross wire is placed so as to divert a great portion of the current from the electro-magnet," had led the lecturer to an investigation read before the Royal Society on the 4th of March, 1880, in which it was shown that by augmenting the resistance upon the electro-magnets 100-fold, valuable effects could be realised, as illustrated graphically by means of a diagram. The most important of these results consisted in this, that the electromotive force produced in a "shunt-wound machine," as it was called, increased with the external resistance, whereby the great fluctuations formerly inseparable from electric-arc lighting could be obviated, and that, by the double means of exciting the electro-magnets, still greater uniformity of current was attainable.

The conditions upon which the working of a well-conceived dynamo machine must depend were next alluded to, and it was demonstrated that when losses by unnecessary wire-resistance, by Foucault-currents, and by induced currents in the rotating armature were avoided, as much as 90 per cent., or even more of the power communicated to the machine was realised in the form of electric energy, and that *vice versâ* the reconversion of electric into mechanical energy could be accomplished with similarly small loss. Thus, by means of two machines at a moderate distance apart, nearly 80 per cent. of the power imparted to the one machine could be again yielded in the mechanical form by the second, leaving out of consideration frictional losses, which latter need not be great, considering that a dynamo machine had only one moving part well balanced, and was acted upon along its entire circumference by propelling force. Jacobi had proved, many years ago, that the maximum efficiency of a magneto-electric engine was obtained when

$$\frac{e}{E} = \frac{w}{W} = \frac{1}{2}$$

which law had been frequently construed, by Verdet ("Théorie Mechanique de la Chaleur") and others, to mean that one-half was the maximum theoretical efficiency obtainable in electric transmission of power, and that one-half of the current must be necessarily wasted or turned into heat. The lecturer could never be reconciled to a law necessitating such a waste of energy, and had maintained, without disputing the accuracy of Jacobi's law, that it had reference really to the condition of maximum work accomplished with a given machine, whereas its efficiency must be governed by the equation

$$\frac{e}{E} = \frac{w}{W} = \text{nearly } 1.$$

From this it followed that the maximum yield was obtained when two dynamo-machines (of similar construction) rotated nearly at the same speed, but that under these conditions the amount of force transmitted was a minimum. Practically the best condition of working consisted in giving to the primary machine such proportions as to produce a current of the same magnitude, but of 50 per cent. greater electromotive force than the secondary; by adopting such an

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arrangement, as much as 50 per cent. of the power imparted to the primary could be practically received from the secondary machine at a distance of several miles. Professor Silvanus Thompson, in his recent Cantor Lectures, had shown an ingenious graphical method of proving these important fundamental laws.

The possibility of transmitting power electrically was so obvious that suggestions to that effect had been frequently made since the days of Volta, by Ritchie, Jacobi, Henry, Page, Hjorth, and others; but it was only in recent years that such transmission had been rendered practically feasible.

Just six years ago, when delivering his presidential address to the Iron and Steel Institute, the lecturer had ventured to suggest that "time will probably reveal to us effectual means of carrying power to great distances, but I cannot refrain from alluding to one which is, in my opinion, worthy of consideration, namely, the electrical conductor. Suppose water-power to be employed to give motion to a dynamo-electrical machine, a very powerful electrical current will be the result, which may be carried to a great distance, through a large metallic conductor, and then be made to impart motion to electro-magnetic engines, to ignite the carbon points of electric lamps, or to effect the separation of metals from their combinations. A copper rod 3in. in diameter would be capable of transmitting 1,000 horse-power a distance of say 30 miles, an amount sufficient to supply one quarter of a million candle-power, which would suffice to illuminate a moderately-sized town." This suggestion had been much criticised at the time, when it was still thought that electricity was incapable of being massed so as to deal with many horse-power of effect, and the size of conductor he had proposed was also considered wholly inadequate. It would be interesting to test this early calculation by recent experience. Mr. Marcel Deprez had, it was well known, lately succeeded in transmitting as much as 3 h.-p. to a distance of 40 kilometers (25 miles) through a pair of ordinary telegraph wires of 4mm. diameter. The results as obtained had been carefully noted by Mr. Tresca, and had been communicated a fortnight ago to the French Academy of Sciences. Taking the relative conductivity of iron wire employed by Deprez, and the 3-inch rod proposed by the lecturer, the amount of power that could be transmitted through the latter would be about 4,000 horse-power. But Deprez had employed a motor-dynamo of 2,000 volts, and was contented with a yield of 32 per cent. only of the power imparted to the primary machine, whereas he had calculated at the time upon an electromotive force of 200 volts, and upon a return of at least 40 per cent. of the energy imparted.

In March, 1878, when delivering one of the science lectures at Glasgow, he said that a 2in. rod could be made to accomplish the object proposed, because he had by that time conceived the possibility of employing a current of at least 500 volts. Sir William Thomson had at once accepted these views, and with the conceptive ingenuity peculiar to himself, had gone far beyond him, in showing before the Parliamentary Electric Light Committee of 1879, that through a copper wire of only $\frac{1}{2}$ inch diameter, 21,000 horse-power might be conveyed to a distance of 300 miles with a current of an intensity of 80,000 volts. The time might come when such a current could be dealt with, having a striking distance of about 1·2 feet in air, but then, probably, a very practical law enunciated by Sir William Thomson would be infringed. This was to the effect that electricity was conveyed at the cheapest rate through a conductor, the cost of which was such that the annual interest upon the money expended equalled the annual expenditure for lost effect in the conductor in producing the power to be conveyed. It appeared that M. Deprez had not followed this law in making his recent installations.

Sir William Armstrong was probably first to take practical advantage of these suggestions in lighting his house at Cragside during night-time, and working his lathe and saw-bench during the day, by power transmitted through a wire from a waterfall nearly a mile distant from his mansion. The lecturer had also accomplished the several objects of pumping water, cutting wood, hay, and swedes, of lighting his house, and of carrying on experiments in electro-horticulture from a common centre of steam-power. The results had been most satisfactory; the whole of the management had been in the hands of a gardener and of labourers, who were without previous knowledge of electricity, and the only repairs that had been found necessary were one renewal of the commutators and an occasional change of metallic contact brushes.

An interesting application of electric transmission to cranes, by Dr. Hopkinson, was shown in operation.

Amongst the numerous other applications of the electrical transmission of power, that to electrical railways, first exhibited by Dr. Werner Siemens, at the Berlin Exhibition of 1879, had created more than ordinary public attention. In it the current produced by a dynamo-machine, fixed at a convenient station and driven by a steam-engine or other motor, was conveyed to a dynamo placed upon the moving car, through a central rail supported upon insulating blocks of wood, the two working-rails serving to convey the return current. The line was 900 yards long, of 2ft. gauge, and the moving car served its purpose of carrying twenty visitors through the Exhibition each trip. The success of this experiment soon led to the laying of the Lichterfelde line, in which both rails were placed upon insulating sleepers, so that the one served for the conveyance of the current from the power station to the moving car, and the other for completing the return circuit. This line had a gauge of 3ft. 3in., was 2,500 yards in length, and was worked by two dynamo machines, developing an aggregate current of 9,000 watts, equal to 12 horse-power. It had now been in constant operation since the 16th of May, 1881, and had never failed in accomplishing its daily traffic. A line $\frac{1}{2}$ a kilometer in length, but of 4ft. $8\frac{1}{2}$in. gauge, was established by the lecturer at Paris in connection with the Electric Exhibition in 1881. In this case two suspended conductors in the form of hollow tubes with a longitudinal slit were adopted, the contact being made by metallic bolts drawn through these slit tubes, and connected with the dynamo machine on the moving car by copper ropes passing through the roof. On this line 95,000 passengers were conveyed within the short period of seven weeks.

An electric tramway, six miles in length, had just been completed, connecting Portrush with Bush Mills, in the north of Ireland, in the installation of which the lecturer was aided by Mr. Traill, as engineer of the company, by Mr. Alexander Siemens, and by Dr. E. Hopkinson, representing his firm. In this instance the two rails, 3ft. apart, were not insulated from the ground, but were joined electrically by means of copper staples and formed the return circuit, the current being conveyed to the car through a tee iron placed upon short standards, and insulated by means of insulite caps. For the present the power was produced by a steam engine at Portrush, giving motion to a shunt-wound dynamo of 15,000 watts = 20 horse-power, but arrangements were in progress to utilise a waterfall of ample power near Bush Mills, by means of three turbines of 40 horse-power each, now in course of erection. The working-speed of this line was restricted by the Board of Trade to ten miles an hour, which was readily obtained, although the gradients of the line were decidedly unfavourable, including an incline of two miles in length at a gradient of 1 in 38. It was intended to extend the line six miles beyond Bush Mills, in order to join it at Dervock Station with the north of Ireland narrow-gauge railway system.

The electric system of propulsion was, in the lecturer's opinion, sufficiently advanced to assure practical success under suitable circumstances—such as for suburban tramways, elevated lines, and above all lines through tunnels, such as the Metropolitan and District Railways. The advantages were that the weight of the engine, so destructive of power and of the plant itself in starting and stopping, would be saved, and that perfect immunity from products of combustion would be insured. The limited experience at Lichterfelde, at Paris, and with another electric line of 765 yards in length, and 2ft. 2in. gauge, worked in connection with the Zaukerode Colliery since October, 1882, were extremely favourable to this mode of propulsion. The lecturer, how-

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ever, did not advocate its prospective application in competition with the locomotive engine for main lines of railway. For tramways within populous districts, the insulated conductor involved a serious difficulty. It would be more advantageous under these circumstances to resort to secondary batteries, forming a store of electrical energy carried under the seats of the car itself, and working a dynamo machine connected with the moving wheels by means of belts and chains.

The secondary battery was the only available means of propelling vessels by electrical power, and considering that these batteries might be made to serve the purpose of keel ballast, their weight, which was still considerable, would not be objectionable. The secondary battery was not an entirely new conception. The hydrogen gas battery suggested by Sir Wm. Grove in 1841, and which was shown in operation, realised in the most perfect manner the conception of storage, only that the power obtained from it was exceedingly slight. The lecturer, in working upon Sir William Grove's conception, had twenty-five years ago constructed a battery of considerable power in substituting porous carbon for platinum, impregnating the same with a precipitate of lead peroxidised by a charging current. At that time little practical importance attached, however, to the subject, and even when Planté, in 1860, produced his secondary battery, composed of lead plates peroxidised by a charging current, little more than scientific curiosity was excited. It was only since the dynamo machine had become an accomplished fact that the importance of this mode of storing energy had become of practical importance, and great credit was due to Faure, to Sellon, and to Volckmar, for putting this valuable addition to practical science into available forms. A question of great interest in connection with the secondary battery had reference to its permanence. A fear had been expressed by many that local action would soon destroy the fabric of which it was composed, and that the active surfaces would become coated with sulphate of lead, preventing further action. It had, however, lately been proved in a paper read by Dr. Frankland before the Royal Society, corroborated by simultaneous investigations by Dr. Gladstone and Mr. Tribe, that the action of the secondary battery depended essentially upon the alternative composition and decomposition of sulphate of lead, which was, therefore, not an enemy, but the best friend to its continued action.

In conclusion, the lecturer referred to electric nomenclature, and to the means for measuring and recording the passage of electric energy. When he addressed the British Association at Southampton, he had ventured to suggest two electrical units additional to those established at the Electrical Congress in 1881, viz., the watt and the joule, in order to complete the chain of units connecting electrical with mechanical energy and with the unit-quantity of heat. He was glad to find that this suggestion had met with favourable reception, especially that of the watt, which was convenient for expressing in an intelligible manner the effective power of a dynamo machine, and for giving a precise idea of the number of lights or effective power to be realised by its current, as well as of the engine-power necessary to drive it; 746 watts represented one horse-power.

Finally, the Watt meter—an instrument recently developed by his firm—was shown in operation. This consisted simply of a coil of thick conductor suspended by a torsion wire, and opposed laterally to a fixed coil of wire of high resistance. The current to be measured flowed through both coils in parallel circuit, the one representing its quantity expressible in amperes, and the other its potential expressible in volts. Their joint attractive action expressed therefore volt-amperes or watts, which were read off on a scale of equal divisions.

The lecture was illustrated by experiments, and by numerous diagrams and tables of results. Measuring instruments by Professors Ayrton and Perry, by Mr. Edison, and by Mr. Boys were also exhibited.

The fourth lecture of this series will be delivered on **Thursday, the 5th of April, by Dr. J. Hopkinson, F.R.S., M. Inst. C.E., who will then deal with "Some Points in Electric Lighting."**

THE COUPLING UP OF DYNAMOS AND THE TRANSMISSION OF POWER.*

BY M. E. HOSPITALIER.

When transmission is effected by a machine placed at each end of a double line, the losses which are liable to occur, owing to imperfect insulation of the line, diminish the current which traverses the receiving machine, and, consequently, reduce at the same time the effective work per unit of time and the return.

FIG. 1.—Connections of the machines at Miesbach and Munich. G indicates the generator, R the receiver. The loss in the line diminishes the current in the receiver, and, consequently, the effective work and return. Bad insulation of the line is prejudicial.

FIG. 1.

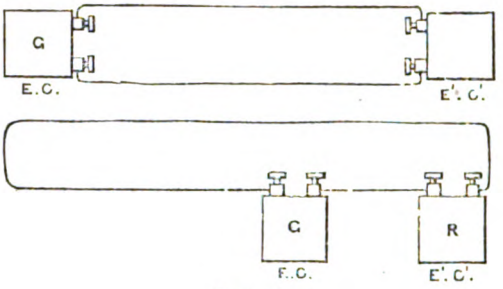


FIG. 2.

FIG. 2.—Connections of the dynamo machines in the workshops of the Northern (of France) Railway. G indicates generator, R receiver. The losses on the line do not influence the necessary equality between the current traversing the generator and that traversing the receiver. These losses diminish the resistance of the line, and increase the effective work. Bad insulation of the line is favourable.

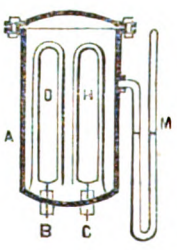
There is no comparison between two cases, 1, where the two machines are placed side by side, and connected together by a short and perfectly insulated wire; and, 2, by a telegraph line. In this case the more or less perfect insulation of the line has no influence on the always perfect equality existing between the current traversing the generator and that traversing the receiver. The result is that the return is independent of the insulation, and only depends on the relation between the E.M.F.'s, while the effective work increases as the insulation of the line diminishes.

A HIGH-PRESSURE ELECTRIC ACCUMULATOR OR SECONDARY BATTERY.†

BY FREDK. J. SMITH.

The modification of the gas-battery of Sir W. Grove which the author has devised is as follows:—

The gas-battery of Sir W. Grove, as usually made, when used as an accumulator, owing to the small quantity of gases that it holds, soon runs down when in use. In order to make its life longer, the author puts the gases under a high pressure. By this means a large quantity of gas can be stored in a suitably constructed instrument. The earliest form of battery, and this has been at work (*i.e.*, has been charged and discharged as an accumulator) for eighteen months, is shown in the cut. A is a strong lead vessel, well lined with rubber varnish, to prevent any solution of the lead being formed. O, H are platinised platinum cylinders, in inverted tubes held in their proper position by pieces of rubber. M is a manometer. The terminals B, C are brought through insulating stoppers. A 10-per-cent. mixture of sulphuric acid and water is used as the liquid. With this arrangement a pressure of seven atmospheres can be easily used; and thus the tubes, one of which has twice the capacity of the other, can contain sixty-four times the gas that they would do at the ordinary pressure. A second form has been made by Messrs. Becker and Co. for the



* Note on the influence exerted by the mode of coupling up dynamo-electric machines in experiments on the transmission of power to a distance, presented to the Academy of Sciences at Paris.

† Published in *Phil. Mag.* for March, 1883.

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author. In this a U-shaped glass tube is used, the manometer being attached to the bend, and the sheets of platinum being fused into each leg. This form, although well suited for lecture purposes, will bear but a small pressure. A curious point observed, and one that is now being carefully worked out, is that the E.M.F. appears to vary much with the pressure.

The author has, in addition to the experiment described, charged small Faure or lead secondary batteries under pressure, the result being that the life of the battery is lengthened by being charged under pressure. Sufficient data have not as yet been collected concerning the variation of the E.M.F. under pressure, and the behaviour of the lead battery under pressure, to put into print. Should others experimentalise in the direction of high-pressure accumulators, a caution must be added with regard to the air-space left in the lead chamber, that quantity of air must be left which may be compressed, say, to seven atmospheres of pressure before the gas in O rises outside.

Oxygen produced by electrolytic action almost instantly acts on the best india-rubber tubing or varnish, causing splits and cracks to be formed in it. The chambers are now made of lead, to which a harder metal has been added.

THE PATENT BILL.

The Bill to amend the Patent Laws is now printed. Its chief points are as follow:—The Board of Trade is for the future to have the control over patents. The Bill revokes the Act appointing the Commissioners of Patents, and in their place appoints a "Controller-General of Patents, Designs, and Trade Marks," who is to act under the superintendence and direction of the Board of Trade. The method of applying for a patent has been altered. According to the proposed new method the applicant has to file with his application a specification describing his invention. This may either be "provisional" or "complete." Supposing it to be adopted, the provisional specification is to be referred by the controller to an examiner, who would report whether the invention is proper subject-matter for a patent, and whether it has been fairly described; also if the documents have been properly prepared. In case of an adverse report, the application may be refused, or the applicant may be required to amend his application; but there is in either case an appeal to the law officers. As soon as the application is accepted, the applicant receives provisional protection for twelve months, dating from his application. Nine months after the commencement of provisional protection he has to file a "complete specification," setting out more fully the nature of his invention, and this is examined in the same way as the provisional, to see that the two specifications agree, and that their claims are the same. In both specifications the "claims" must be distinctly stated. On the "acceptance" of the complete specification the fact is to be advertised, and the documents opened to public inspection. This acceptance must be complete within twelve months, or the application becomes void. For two months after the acceptance, the patent is liable to opposition before the law officers, who may refuse the grant. If there is no successful opposition, three months after acceptance the patent is sealed. If a complete specification is filed in the first instance with the application, the procedure is nearly similar. The fees are—on application, £1; on grant, £3; and the patent is good for four years. At the end of four years there is a fee of £50; at the end of eight, a fee of £100. The total duration of the patent is, as now, 14 years. The Bill also provides for the publication of an illustrated journal of patents, and the transference of the Patent Office Museum to the Science and Art Department. We shall refer to the Bill at greater length in a future issue. The subject is a very important one, and should be well discussed. The *Daily News* learns that when the Patents Bill comes before the House Mr. Anderson will, in some tangible form, raise the question of the expediency of greatly diminishing the cost of patents.

ELECTRIC LIGHTING AND LOCOMOTION.*

(CONCLUDED FROM PAGE 430.)

Now, suppose we have one of our motors adjusted to run without any winding on the field-magnets, and imagine we wind the field-magnets in such a direction that the motor would tend to turn in the opposite direction when a current passed round the coil wound round the field-magnets, what would happen? Why, if the magnetism induced in the field-magnets by the current flowing round it were stronger than the opposite magnetism induced in the iron by the armature, we should have the very curious and novel result that the direction of the motor could be reversed by simply short-circuiting with a thick piece of wire, the current flowing round the field-magnets, and this result we have practically attained, as I will now show you. [Experiment shown.] Allow the current to flow through the armature and field-magnets, and the motor runs one way; let it only flow through the armature alone, and the motion is instantaneously reversed. Merely pressing down the key then reverses the motion. Hitherto the much more complicated arrangement of reversing the electric connections between the armature and field-magnet has always been thought necessary to reverse the direction of motion of a motor.

We have in the preceding considered that the magnetism produced by the coil on the field-magnets was greater than that produced by the induction of the armature itself, and so determined the direction of motion. But suppose that is not the case, then what will happen? Why, then the current passing through the coil on the field-magnets will be resisting the motion, and so will be helped on. But that, as we saw before, is exactly the condition necessary for governing. The armature then and the iron of the field-magnets acts as a motor, while the armature and the coil wound round it act as a dynamo, and if the resistance of the coil, which we make of fine wire, and as a shunt to the armature, is of proper resistance, and the required speed of the motor is the critical speed of the dynamo, the governing of our motor may be made fairly perfect with only one circuit on it.

Hitherto we have been dealing with motors especially intended always to run at one speed whatever amount of work they might be doing. We next come to motors for electric tramcars, tricycles, &c., designed to run at any desired speed forwards or backwards.

I have spoken about the set of the brushes relatively to the field-magnet, and the set, or "lead" as it is technically called, is of great practical importance, since on the amount of lead depends which way the motor revolves or whether it revolves at all. Although the fact that the direction of rotation could be reversed by a sufficient change in the lead was well known, the importance of varying the lead in motors for different speeds appears to be little attended to, since it is impossible as a rule in motors, from their construction, to make small changes in the lead. In our motors, on the other hand, the flat brush-holder can be revolved forwards or backwards by hand through any angle, so that any lead forwards or backwards is obtainable, and in our larger motors, of which I have a sample here, the lead can be made anything we like simply by moving a handle, such as a locomotive engine-driver is accustomed to use for acting on the link-motion of his engine. In fact, by moving the handle forwards or backwards any speed, in either direction, is obtainable. We can, even when the motor is running, shift the brushes relatively to the field-magnet together with which they are rotating, and consequently with only one pair of brushes to give any lead forwards or backwards we desire. In other cases we alter the lead by means of a wheel and screw, and so get very easily a very accurate adjustment. A table of speeds can be engraved, showing the position the handle should be in for 500 revolutions a minute, or 700 revolutions a minute, &c.

On the last occasion I showed you photographs of all the principal electric railways, and we saw that in some cases the current went by an auxiliary insulated rail passed through the motor under the train, and came back by the rails. In other cases both the going and return wires were of the nature of stout overhead telegraph wires, and a running connection between the motor on the tramcar and these wires was kept up by two small jockeys, that were pulled along the telegraph wires by wires attached to the tramcar. In a third system, the going and return conductors were simply ordinary rails on which the train runs, the insulation produced by the rails merely resting on wooden sleepers having been found sufficient for a length of one or two miles. As you will see from the photographs that I now project on the screen, this last and simplest plan has been adopted for the Portrush Railway, near the Giant's Causeway, in Ireland. This electric railway, Mr. Traill (the chairman) has been so good as to write to me, "runs on a footpath, or trampath, by the side of

* Lecture II., delivered by Professor Ayrton, F.R.S., at the London Institution, March 15, 1883.

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the road, which has been widened for the purpose from 24ft. to 27ft. The path is 7ft. wide, leaving 20ft. for the carriage-way. We first tried," he says, "sending the current by one rail, returning by the other rail, after passing across by the car, and for this purpose had laid the rails in asphalte with thick felt underneath, but we found that the leakage, especially in wet weather, was too great to justify us in continuing that kind of insulation for six miles." Now, this is exactly the result I predicted in my lectures on electric railways delivered last year, and in order to make the difficulty quite clear to you, I will show you the experiment I then showed to prove this. A portion of the going wire conveying the current working the motor is driving the circular saw, as you observe, wrapped round this bit of wood, and a portion of the return wire round this other piece of wood. As the two pieces of wood are dry there is very little leakage from the wire on the one to the wire on the other, although the wire wrapped round each is bare. If, however, without allowing these pieces of wood to touch one another, I immerse the ends of them in this vessel of water I shall produce the same effect as if a shower of rain fell at one end of the electric railway. Now, observe what happens, the motor immediately begins to go more slowly. Let me immerse them further, which will correspond with the rain becoming more general over the line, and the motor goes still more slowly, and now the motor stops altogether, so much of the current, in fact, leaking from the going to the return wire through the water that sufficient does not pass through the distant electro-motor to keep up its motion.

How, then, has this difficulty been overcome at the Giant's Causeway? Mr. Traill's letter tells us. He says:—"We have therefore placed a third rail of iron on wooden props close into the fence, so that a brush striking out from the car on a steel bar runs along the top of this third rail, which is about 15 inches from the ground." He goes on to say that this third rail is embedded in tar on the tops of the posts, and that when, in addition, pieces of the new insulating material ("insulite") are introduced between the rail and the wooden posts they expect the insulation will be perfect. He adds:—"At present we can run for over two miles on the road up and down hill gradients as great as 1 in 35. We took six tons up that incline the other day. We are about to erect turbines at the waterfall above Bushmills, which will give us from 60 to 100 horse-power, and will generate the current there about half a mile from our main line at Bushmills. We have powers by our Act of Parliament to construct a railway from Bushmills to Dervock (inland about seven miles) almost at right angles to the line of tramway on the sea coast. As the waterfall is near the junction of railway and tramway we intend to use it for the railway as well, as the works will do for both. We are limited by an Act to 10 miles an hour on the tramway, but will have no difficulty in going to 20 or 25 miles an hour on the railway, which has also the advantage of being level the entire way."

But although they have succeeded at Portrush in overcoming the difficulty of leakage by using this third insulated rail, resting on posts 15in. above the ground, such a system presents, you will easily see, great inconveniences for ordinary railways, since at every crossing there would be this raised rail in the way of the trains, and an even greater objection is the risk that it introduces, that any one can, from carelessness or malice, by resting, say, a crowbar against this raised insulated rail, send all the electricity to the earth and so cut off all electric power from all the trains either in front or behind.

On the other hand, the plan of using stout telegraph wires, with running jockeys to keep up continuous electric connection between these wires and the moving train, would present great mechanical difficulties if the trains were going at 60 miles an hour.

What, then, do we propose? Professor Perry's and my plan is this: we electrically subdivide the rubbed rail into a number of sections all fairly, but by no means perfectly, insulated from the ground. We do not apply our electricity directly to this rubbed rail, but, instead, to a well-insulated conductor, which may be buried underground or may be insulated by resting like a telegraph line on insulators or posts, and we arrange that whenever a train enters on to any section, it automatically makes an electric connection between that section of the rubbed rail and the well-insulated conductor which supplies the power, and at the same time automatically cuts off the electric power from the section the train has just left, and in this way we confine the leakage of electricity to that section on which the train is at any particular time, and so reduce the leakage and waste of power on the longest electric railway to less than it is at present on the shortest line constructed on the Berlin plan.

But not only does a train on entering any section automatically turn on the electric power to that section, and cut it off from the one just left, but it accomplishes something more; it blocks absolutely the section just left. Let us take an example:—Suppose a train is passing from section A to section B, then not only is the power automatically turned on to section B and cut off from section A, but no following train entering on section A can receive power and move on as long as the train in front is on section B. It is not until the preceding train has passed into section C that the following train can proceed along section A. And, in addition, whenever a train is approaching too near a train in front, and in consequence finds itself deprived of driving power, it is automatically, by a special plan we have contrived automatically, powerfully braked.

Whenever, then, a train—it may be even a runaway engine—enters on a blocked section, not only is all motive power withdrawn from it, but it is in addition automatically powerfully braked quite independent of the action of signalman, guard, or engine-driver, even if the latter two be present, which, bear in mind, is not at all necessary with our electric railway. No fog nor colour blindness, nor different codes of signals on different lines, nor mistakes arising from the exhausted, nervous condition of overworked signalmen can with our system produce a collision. The English system of blocking means merely giving an order to stop, but whether this is understood or intelligently carried out is only settled by the happening or non-happening of a subsequent collision. Our absolute automatic block acts as if the steam were automatically shut off, and the brake put on whenever the train is running into danger; nay, it does more than this, it acts as if the fires were put out, and all the coal taken away, since it is quite out of the power of the engine-driver, if there be one, to re-start the train until the one in front is at a safe distance ahead.

At present much household work is done by hand, simply because there are no easily-worked machines for doing it. The old knife-board has given way to the rotary knife-cleaner, but even that requires a certain amount of grinding to give the knives a polish, so that for large establishments a knife-cleaner boy is still necessary. The blacking of boots, the blacking of grates, the cleaning of doorsteps, &c., are all done in a most laborious way by hand. (I might almost say the operation seems not to be confined to hand, judging from the generally smutty appearance of Sarah Anne after the process.) Now, there can be no doubt that very shortly electricity will be supplied, as gas is now supplied, to houses for lighting purposes, and when this has been accomplished, the same wires that convey the electricity for lighting during the night will be employed in the day to convey the power to work electric-motors to turn rotary knife-cleaners, to turn a wheel for the blacking of boots, and a small motor carrying a brush like the one in my hand will simply be passed by the servant all over the grate for the purpose of giving it a good black polish. The black-lead brush will then be taken off, and replaced by the blacking brush for the boots, and later on in the day a rotary flannel will officiate for the door-steps.

The high price of land in towns necessitates gas works being in the suburbs, so in the future the electric works must be in the country, and probably farther away from the towns than even gas works are at the present time, because not only will great economy be so attainable, but the town will be freed from the smoke of the engines to drive the dynamo machines or producers of electric current, and by that time we shall have begun to realise that a smoky atmosphere is a poisonous atmosphere; further, if our dynamos are far away in the country advantage can also be taken of natural sources of water power.

The transmission, then, of power by electricity is not only a problem which must be solved, but is one which calls for immediate solution.

For the economic electric transport of power we must produce, as I have explained, a great difference of potentials by a dynamo at the place where the power is obtainable—in the suburbs where, for example, is the steam engine or water wheel—and employ some mechanism which can be worked by this great difference of potentials at the place where the power is to be utilised—that is, in the town. There is no difficulty in arranging a dynamo wound with fine wire, or a set of dynamos in series with one another, to produce any difference of potentials required; but there is a far greater difficulty in using this great difference of potentials at the town end of the line. If lamps and motors of the present construction are used they would have to be put in series, but in that case if the current is stopped passing through one it will be stopped passing through all. This difficulty can to a great extent be avoided by using "cut-outs," as I described to you in my last lecture. At the same time nobody would be perfectly satisfied that his supply of electric power should depend on the good working of all the electric apparatus in the same street, much less that it should depend on the good working of all the electric apparatus in the same town. We are content that our supply of gas or water should depend on the good working of the gas or

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water works, but we could not tolerate the possibility of Betsy Jane, in Moorgate-street, from some carelessness or other, being able to cut off our supply at the London Institution. That Jack Frost should stop our supply is bad enough, but Betsy Jane—no!

What, then, are we to do? High difference of potential we must use, and we cannot work the lamps and motors in parallel unless they have a resistance of tens of thousands of ohms, in fact, are of a totally different description from the lamps and motors of the present day. The solution was first suggested by Sir William Thomson in 1881, and, I am happy to say, will very shortly be carried out in Paris by Professor Perry and myself, under the auspices of the French Electrical Storage Company. It is to use the small current and great difference of potentials to charge a very large number of accumulators, in series, in the town, and to discharge them in sets, as shown in the figure, each set supplying the energy for one street, or, possibly, for one district. Of course, the going and return wires between the dynamo and accumulators must be separately insulated, and put so far apart that there is no fear of a man or an animal accidentally touching both. If, in addition, it is feared that although this precaution is taken still somebody may touch a leading wire, say A, coming from somewhere near one end of the accumulators, while another person may accidently touch a leading wire, B, coming from somewhere near the other end of the accumulators, and so both receive a fatal shock, this may be also entirely avoided by electrically disconnecting the various sets of accumulators from one another, and from the main charging wires coming from the dynamo before they are connected respectively to the local leads in the streets for being discharged.

Suppose a thousand accumulators were thus employed, and a charging current of 33 amperes were used. To balance the electromotive force of the accumulators about 2,100 volts would be required. If the resistance of each cell were 0·005 of an ohm during charging, then 165 volts difference of potentials would be required to send a current of 33 amperes through this resistance, or a total difference of potentials of 2,265 volts would have to be maintained at the terminals of the accumulators. Hence about 100 horse-power would be put into them.

The next question that arises is, what size of conducting wire is it proper to use to convey a current of 33 amperes? If the conductor is thin it will certainly not cost much to erect; but, on the other hand, the resistance to the passage of the current will be great, and much of the power will be wasted in the heating of the wire. On the contrary, if the conductor is very thick, there will be practically no waste of power by the heating of the wire, but the capital sunk in erecting it will be excessive. It is clear, then, that there is some thickness which gives us the best results, and Sir William Thomson has worked out this problem for us, and has shown us that the thickness of the conductor proper to be used for any particular current does not depend at all on the length of the conductor, but depends first on the strength of current passing through the conductor; second, on the cost of copper per ton; and third, on the market value of one horse-power supplied for a year. Assuming that good conductivity copper costs £70 per ton, and that the market value of a horse-power is £10 per annum, the proper diameter to give to a conductor conveying a current of 33 amperes comes out to be 32-100ths of an inch, or a trifle over 3-10ths, on the assumption that the current passes for 12 hours out of every 24.

In order to send this 33 amperes through ten miles of going and ten miles of return copper wire, 32-100ths of an inch in diameter, as well as through the 1,000 accumulators, will necessitate the dynamo producing a difference of potentials of 2,654 volts. Under these circumstances calculation shows that about 17 horse-power would be lost in heating the line wires, about seven horse-power in charging the accumulators, and about a further 25 horse-power in the dynamo itself, which is in the country. 142 horse-power must, therefore, be given by the steam engine or water wheel to this dynamo.

We come to the conclusion, then, that if 142 horse power is given by the engine to the dynamo, 117 is given up by the dynamo to the wires; 100 is given up by the wires to the accumulators in the town, and 93 is stored up in the accumulators for future use, the total horse-power usefully stored up in the accumulators being in this particular case about 65 per cent. of that given to the dynamo by the engine.

The world thinks of a current of electricity as it thinks of a current of water. Now, there is this very essential difference between the supply of electricity to houses and the supply of gas or water to houses. When gas is supplied, you have only to deal with the *quantity* supplied; you are not going to use the pressure of the gas to do work, even if the gas is to be used in a gas engine. It is only the burning of the gas that you are interested in. You are really dealing, therefore, with *quantity* of gas. Similarly when water is supplied, nobody cares very much about the pressure so long as it is sufficiently high to reach the top story of his house. But if the pressure is 700lb. per square inch, as used by Sir William Armstrong, or 1,500lb. per square inch, as used by Mr. Tweddell, then the pressure becomes a very serious matter. Ordinary water is mainly used for drinking and washing purposes, and although this high pressure of water could also be used for drinking and washing, nobody but a millionaire would think of such extravagance; for it is not merely water, but water at a pressure of 1,500lb. per square inch that is supplied, and every cubic foot of water received per minute at that pressure by the consumer means 6 horse-power. In that case the pressure is all important, and for measurement you must take the quantity of water multiplied py the pressure. And although mere quantity of water may be important for washing purposes, we know of no purpose requiring mere quantity of electricity; it is needed as a source of energy to drive a motor, or to produce light, and the *amount of energy*, not the *quantity of electricity*, is what must be measured.

In any proper commercial recording meter for electricity a record must be kept, therefore, of two things—the quantity of electricity and the pressure which it is supplied at. Now, the electric meter or "ergmeter," as we call it, designed by Prof. Perry and myself for this purpose, is hanging up here. It consists of a fairly good pendulum clock, possessing a seconds hand. The pendulum bob has been taken off, and a coil of wire of about 1,000 ohms resistance substituted in place of it. Fixed on the case of the clock, near the fine wire coil, there is a coil of thick wire through which the main current passes.

The current passing through the pendulum bob depends on the difference of electric pressure at the main where it enters the house and leaves the house, whereas the current passing through the thick wire coil is the total current works the lamps and motors. Now, the electric power being supplied to the house depends on the strength of one of these currents multiplied by by strength of the other, and it can be proved mathematically as well as, of course, experimentally, that the total quantity of electric energy supplied to the house during any time, whether sometimes in the form of high pressure and small current, or sometimes in the form of small pressure and large current, is exactly proportional to the loss of the clock in that time. The number of minutes of slowness is the measure of electric energy supplied to the house, and is what should be charged for. An ordinary clock may doubtless lose a few minutes in a week, but we of course make the loss which we want to observe much greater than this. An ordinary clock wants winding up every week, but this of course is easily got over, and if experience in the future shows that the observations of the ergmeter by the electric inspector are only taken at distant periods that the clock would lose more than twelve hours between his visits, due to its measuring the electric energy supplied to the house in the meantime, then a hand will be added which takes, if we like, a day to make one complete revolution.

In the legislation which has recently taken place in connection with the commercial supply of electricity, a mistaken notion has grown up that the *quantity* of electricity is what should be recorded, and not electric energy. Now, not only is this bad in that it prevents an estimate being easily formed of the relative prices charged by the different companies for the supply of electricity, since the different companies use normally very different electric pressure, but even the most perfect system of governing dynamos, such as I described to you last time, or of laying the wires under the streets, such as has been suggested by Mr. Edison, will not enable the electric pressure at any house to be kept absolutely constant during the day, even if the electric pressure at the mains where they leave the dynamo is kept absolutely constant.

That is to say, with any system that has been hitherto suggested it is physically impossible, and, therefore, I need hardly say, cannot be made possible by legislation, to keep the pressure at a considerable distance from the producing station absolutely independent of the number of intermediate houses that are consuming electric power. In my opinion, then, we should not tolerate either the recording of, or the paying for the *quantity* of electricity supplied, but we must record and pay simply for electric power.

Two years ago the storage of electric energy in black boxes, and their power taken out of them by Sir Wm. Thomson, may have passed before the minds of the public as one of those mere seven days' wonders which in these latter times have become so common. But to the scientific man, who could foresee the possibilities connected with the electrical storage of power, these experiments of Sir Wm. Thomson were of pre-eminent importance.

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The two latest employments of electricity stored in Faure-Sellon-Volckmar accumulators are in the boat "Electricity," which many may have seen running last Saturday at Kew, and a photograph of which I now project on the screen, and the electric tricycle of Professor Perry and myself. In the tricycle no work is done by the rider, but little black boxes carried on the base-board contain the stored electric energy pretty much in the same way as a horse's body contains its breakfast of oats and hay, with the difference that with the accumulator it is the receptacle which has weight, so that neither in receiving its feed in the morning or discharging its power during the day does the accumulator gain or lose in its weight. By means of a tap the rider can turn on more or less electricity and go faster or slower. The faster he is going the less is the waste of the electricity, although, of course, the consumption of power is greater than when going slowly—that is to say, the faster the tricycle goes the more efficient is the whole arrangement. On the other hand, when the electric supply tap is turned off and the tricycle is at rest the waste in the accumulators is not large, and the tricycle stands for days ready for immediate use without any waste analogous with an unused horse "eating his head off."

But although the electric tricycle ceases using up its last supply of electricity when it stops, and requires no feeding while motionless, still it must be fed periodically if used regularly. But very shortly I expect to see the tricyclist dismounting at his inn—with the sign, perhaps, of the "Faraday"—having the certainty that in the morning he will find his accumulators fully charged up with the electric machine of the inn, also used for lighting and agricultural purposes. I feel also sure that when this is the case the charge in his bill for the electric feed will be one of the smallest items entered.

Let us now adjourn to the library to see our electrically-lighted and driven tricycle in actual operation, and which the size of this lecture hall, large though it be, prevents my showing you here, and, that you may judge of the tricycle's power, I may mention that with it we have actually run a measured mile in 8¾ minutes, when the tricycle was carrying a man of average weight and the necessary supply of electric accumulators to propel it for about two hours.

What stored electricity can do the accumulators before you, kindly lent by the Electrical Power Storage Company, have shown. What the future of electrical locomotion may be who can say? The subject is yet young, very young. Improvements on what I have talked about to you to-night will no doubt be made. Perhaps Professor Perry and myself already see how some progress may be made. But at all events, I trust I have shown you that electric locomotion is already so far developed as to be a real commercial subject of discussion.

ELECTRIC LIGHTING AND THE TRANSMISSION OF POWER.

On Saturday evening, the 17th inst., Mr. Reckenzaun, C.E., delivered a lecture upon the above subjects at the Working Men's College, Great Ormond-street. Sir Daniel Cooper presided, and introduced the lecturer, than whom he said no one was more able to explain the subject upon which he was about to speak. After some introductory remarks, the lecturer said that most of the great discoveries and inventions had had difficulties to overcome, and if there were any prejudice against the electric light, it only proved the general rule. Gas had been considered an expensive luxury when first introduced, because people in those days had been accustomed to darkness. As, however, we became accustomed to more light, and better light, it would be a source of wonder why we had not adopted the better light sooner. That electric light was a nearer approximation to the solar rays than any other artificial light was proved by the fact that it would ripen fruit and act upon sensitised photographic plates. Beyond this the electric arc did not evolve carbonic acid gas, and was, therefore, conducive to health as well as to comfort. Gas was sold by measure; we paid for it at a certain rate per 1,000 cubic feet, and careful people expected to get a definite amount of light out of a certain quantity of gas. The intensity of gaslight was measured by candles, and a gas burner of fourteen candle-power should be equal to fourteen candles, *i.e.*, fourteen standard sperm candles burning 120 grains of sperm per hour. The electric light was also measured by candles, and the simplest means of arriving at that measurement was by the use of the photometer. This process consisted of throwing shadows upon a screen with different lights, the standard light being a candle, the relative value of the other light being determined by its distance from the screen when the two shadows were equal in intensity. The lecturer then described other means of measuring electricity, and defined the units known as volts, amperes, ohms, and watts. The most convenient forms of instruments for measuring electromotive force and currents were, he contended, Messrs. Ayrton and Perry's ammeter and voltmeter, in which the deflections of a needle indicated on the scale what electricity was doing in a circuit. Turning to the question of electric lighting, he referred to the old-fashioned methods of generating electricity by means of the Bunsen and other batteries, and said that the inconveniences attending the manipulation of powerful galvanic batteries, such as the labour of charging them, the evolution of unhealthy gases, and the great expense due to the consumption of materials, had prevented the adoption of electric light under those conditions. It was certain, without the development of Faraday's grand discovery of magneto induction, that it would never have become a commercial success. Referring to the heat of the electric arc, the lecturer said it was the most intense of all the artificial sources of heat. Dr. Siemens had recently constructed a small electrical furnace, in which steel or iron could be fused in a few minutes. The carbon rods of the arc were consumed slowly in the atmosphere, and it was a remarkable fact that the carbon connected to the positive pole of a battery or dynamo machine burned away twice as fast as that connected to the negative pole. As the carbons burnt away the electric arc became gradually longer until the light was extinct. In order to render the light continuous, various automatic regulators had been devised, that applied to the Brush lamp being one of the most perfect, enabling, as it did, the single carbon lamp to burn for eight hours, and the double lamp for sixteen consecutive hours without attention. The Weston lamp, which regulated itself according to the strength of the current, had given very satisfactory results, and produced a steady white light. The Pilsen-Joel lamps had also found favour in this country, and were sometimes fed by accumulators. The lecturer then dealt with the incandescent lamps of Swan, Edison, Maxim, Lane-Fox, and others, and displayed specimens of each in action. The generation of electricity was then dealt with, and, after describing the principle of magneto electric induction, he said that the stronger the pole of a magnet was the greater would be the number of lines of force which radiated from its poles, and the stronger would be the induced currents in the moving coil of a magnet. Also the more rapid the motion the stronger would be the momentary current induced in the coil, and the greater the number of turns in the coil the stronger would be the total current induced by it in moving in the magnetic field. Those points were of vital importance in the action of dynamo-electric generators. In a dynamo machine a number of coils were generally arranged so as to form a ring, which revolved between the poles of a magnet. The ring was known as the armature, and it was necessary to combine in one armature a large number of coils, in order to procure a steady and continuous current. Ring armatures were employed in the Brush and other generators of recent date, as well as those of Gramme. Drum armatures were used for the Siemens and Edison machines, and consisted of coils of wire wound lengthways over a drum instead of round a ring, the wire being carried along the drum parallel to the axis across the end and back along the drum on the opposite side. As fast as the current was generated in the bobbins it was drawn off by the commutator and the contact brushes. The commutators consisted of as many pieces of insulated metal as there were bobbins arranged round the shaft of the machine, the ends of the bobbin wire being soldered on to them. By means of the electric current we were enabled to transmit power to great distances. Streams of water hitherto run to waste, because of the distance from manufacturing towns, would in the future be utilised, and the force would be transported by conductors to do work in the mill or on the farm, to grind the corn, till the land, and light the streets and houses. The Niagara falls alone, it had been calculated, contained a force of 15,000,000 of horse-power. The River Severn, they had been told by Professor Silvanus Thompson, would yield sufficient power to work all the cotton spindles in the United Kingdom, light every city in the country, and yet leave a large margin of waste. One of the first practical applications of the electric transmission of power to a distance had been made at the Vienna Exhibition in 1873, where a dynamo actuated by a gas engine had had its current transmitted through a wire half a mile long to a Gramme machine, which drove a centrifugal pump. More recently, at the Munich Exhibition, Marcel Deprez had transmitted a fraction of a horse-power to a distance of 57 kilometres along an iron telegraph wire. In France experiments had been made with a view of employing ploughs and other agricultural machines worked by electro-motors.

The lecturer then explained the principle of the electric railway and the storage of force for motive power by means of accumulators, and said that Messrs. Sellon and Volckmar had improved upon the accumulators of M. Faure to such a degree that, while a Faure battery weighing 80lb. could store the enormous force of about one million and a half foot pounds, the Sellon-Volckmar cell of the same weight was capable of holding nearly double that energy.

In conclusion the lecturer said that the question relating to the transmission of power to distances gained daily in importance. Thousands of tons of coal were sent from England to almost every quarter of the globe to be used for the production of steam power and artificial light, the cost of transport amounting, in many cases, to more than the original expense of raising it from the bowels of the earth. It had been calculated that the total steam power used in the world amounted to 80,000,000 horse-power, exclusive of steamships, and that the cost of producing that enormous power amounted annually to about twelve hundred millions of pounds sterling. Hence a saving of only ten per cent. in the consumption of fuel would add £120,000,000 to the total riches of the globe every year. The inventors who had done so much to reduce the consumption of coal in the steam engine had contributed, probably, more to the material wealth of mankind than any other benefactors. The processes of still further economising fuel were becoming more difficult, and it behoved us to consider whether the supply would not be exhausted in a few years, and even if it would be for ever available, it was the duty of the scientist to seek every means of lessening its consumption, or to substitute a force which might still further benefit mankind.

On the motion of Sir D. Cooper a vote of thanks was unanimously accorded to the lecturer, who had illustrated his address by numerous experiments and diagrams.

The whole of the electric power used for the purposes of the lecture was supplied from Faure-Sellon-Volckmar accumulators.

River Plate Telephone and Electric Light Company.—At an extraordinary general meeting of this Company, held on Tuesday, the following board was elected:—Colonel Gouraud, chairman; Patrick Carnegy, Esq., C.I.E.; W. Edward Fauvel Powers, Esq.; Hon. Howard Spensley, and Sir Julius Vogel, K.C.M.G.

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ELECTRICAL POWER STORAGE COMPANY (LIMITED)

The annual general meeting of this Company was held on the 21st inst., at the City Terminus Hotel, under the presidency of Sir Daniel Cooper, Bart., K.C.M.G.

The SECRETARY (Mr. Holland Dell) read the notice convening the meeting, and the minutes of the last meeting, which were confirmed.

The CHAIRMAN, in moving the adoption of the report, said, in the course of a detailed speech on the position and prospects of the Company, that it was really the first occasion on which the directors had had the pleasure of meeting the shareholders after an interval sufficient to give evidence of the prospects of the Company. These he was sure they would agree with him, when they had heard the plain statement he proposed to give them, were of an assuring character. After referring to the formation of the Company, in March, 1882, and to their entire acquisition of the Faure patents for the world, he explained that at the time of the original negotiations with the owners of the Faure patents they were under certain engagements as to the sale of their American and Belgian rights. Under these circumstances they were obliged to adopt these engagements with any benefits attaching to them. One, the smaller one, was the sale as regarded Belgium for £20,000 in shares of the Société d'Electricité Belge et Hollandaise. They attached very little value to these shares at the present moment, because the Belgian Company only possessed the rights for the Faure patents, and none for the Sellon-Volckmar, which was the only valuable one commercially. What they would do in the future with the Belgian Company he could not, at present, say. The other engagement was of quite a different character, greater in magnitude, and capable of giving immense returns to this Company. After giving the details of this contract, and the subsequent action taken in America with respect to them, he stated that in May last they sold to the Indian and Oriental Electrical Storage and Works Company the Sellon-Volckmar patents and rights for India and its dependencies, the Straits Settlements, Egypt, and Malta, for £25,000 in cash, £25,000 in royalties, and £50,000 in cash or fully-paid shares, at the option of the directors of the Indian Company. Subsequently, when this Company acquired the Faure patents, they transferred these for their territories to the Indian Company, on condition of their paying the royalties of £25,000 within nine months from that date, and at once issuing to the Company £25,000 in fully-paid shares. This left £25,000, which they had still to pay this Company in cash or shares at their option, and instalments of royalty £15,000. Of this, £5,000 was now paid, leaving that day £10,000 still to come. Having referred to the Australasian patents he continued: The last negotiation I have to tell you of, and I must apologise for the time I am taking up, is that with France, which has been a source of great labour and anxiety to your directors. Finally, we have provisionally sold the French patents to the French Electrical Power Storage Company for £300,000, payable thus:—£72,000 in our own shares, which we propose to accept surrenders of, £70,000 of which we may practically annihilate, so as to leave our capital at £530,000; £3,000 we receive in cash; and the French Company is to pay us by way of royalties at least £25,000 by January 1, 1884, and by January 1 of each succeeding year for five years £40,000, until the whole £300,000 is completed. The provisions of the contract are that until the full payment of £300,000 is made to us we do not part with the patents; that whatever licenses or sub-sales take place, the benefit accrues to us and payments are to be made to us; and that, if in any year, until the whole purchase money is paid, default is made in payment of the amount stipulated, the French Company lose absolutely and altogether all right whatever in the patents, which will remain to us free from any claim whatever of the French Company. I think you will agree with me that we ought to congratulate ourselves upon such a contract, which brings about a present reduction of nearly 12 per cent. of our capital, and secures by future payments, one half of our capital. Negotiations are pending with regard to other countries. He then spoke at length as to the purely manufacturing portion of the business, and expressed his belief that in that respect his report would be equally satisfactory to them. Their intention was to work on steadily as manufacturers. For this purpose they had looked out for eligible premises, and were fortunate in securing a lease for 60 years of their works at Millwall. It was only on the 1st January that they announced their willingness to sell to the public. He then referred in detail to the various items in the balance-sheet, observing as to the stocks in hand that the meaning of the words "present cost prices" was that day by day they were learning their business better, and producing their goods cheaper, but when dealing with their stocks in hand, they had taken as their value only that which they would cost them to make now with their improved facilities and their greater experience. The last item—the balance of profit and loss account—they proposed to write off in full. After going through the profit and loss account, he continued: The nominal balance of profit shown is £346,930, which is in appearance an enormous amount, but, as I have already explained, it really consists mainly of fully paid shares, royalties, and deferred cash payments. Under these circumstances we do not propose to make any distribution, or to declare any dividend, but we do what is the same, or in my opinion far better in an undertaking such as ours, we place ourselves in a position, if you later on pass the resolution to be submitted to you, of virtually reducing our capital by the large sum of £70,000. To demonstrate the usefulness of accumulators for motive power as well as for lighting, we sometime ago purchased a steam launch, took out the steam apparatus, and fitted it with accumulators and a motor, and that little boat has run at all times and in all weathers on the Thames for four months. She has carried many distinguished persons, and none of them but have expressed their satisfaction. I hear that she was figuring at the University Boat Race and showed in good form. Another experiment in motive power was an electrical tramcar; with regard to that car we have still to overcome difficulties of an engineering and mechanical character, but I can state myself, positively, that our accumulators were in no way responsible for any deficiencies at the first trial. They worked, and still work, most admirably for the purpose, and we have found a solution, we believe, to the other difficulties which we met with, and we shall in a few weeks, if not before, be in a position to run our car on the road—letting it take its chance with the others. One last word with regard to the places where our accumulators are finding their way. We have among our customers nearly all the electric light systems. We have supplied them for the Law Courts, to the Swan Company and Messrs. Crompton; we have sent them for use by Siemens Brothers on board an Atlantic steamer; we have supplied them to Brush Companies for some important installations; we have ourselves installed electric light at the offices of the P. and O. Company; we have fitted up the Grand Hotel with 400 lights, which will be running in a few days. The Pullman train to Brighton is lit off our accumulators, and, as as a proof of their successful working, I mention that last week the railway company ordered another set. Perhaps one of the most satisfactory orders we have received was from the Science and Art Department at South Kensington, where a battery had been working under the most severe test for about three months, and only a few days ago we received an official order, not only for the battery they had had in use, but for another larger one. There are also a number of small installations and private installations, which we look to to induce many others to come forward. On the Continent we are supplying the Anglo-Austrian Company with an accumulator of 700 e.h.-p., for the illumination of the Opera House at Vienna. The orders we have received up to date for accumulators, including those required for installations, amount to 6,400 e.h.-p., equal to about £20,000, a fact which, seeing the few weeks we have been selling the accumulators publicly, I regard as most promising. I think these give evidence of what we may look forward to as a universal and extensive employment of our accumulator.

The DEPUTY-CHAIRMAN (Mr. J. S. Sellon), in seconding the motion, thought the position of the Company must be considered as very satisfactory, but if they would allow him to express an opinion he would venture to say that what was now being accomplished was but an earnest on a very limited scale of what might confidently be anticipated when once the immense importance of the accumulator system, and its indispensability under very many conditions of electrical work, was fully realised. Notwithstanding what had been said in some quarters, he made bold to say that a day would come when the most sceptical would be constrained to admit that no business of modern times was likely to excel in importance, in its gigantic application, that which they were now carrying out—namely, of providing a means for electrical storage, and the safe control and the efficient utilisation of this great power. With regard to the batteries which had now, practically only within the past few weeks, made their *début* before the public, the Company with which they were now associated launched them forth, not as having attained that absolute perfection in detail which could only be brought about by long experience, but as having attained a degree of perfection which warranted their being issued to the public. After referring to the energy with which the affairs of the Company had been conducted, and speaking especially of the perseverance of Mr. Volckmar, he expressed his belief that many of them would live to see electrical energy going ahead of every other known power. He did not think it was possible for them to realise in the near future the working of mills, of railways, and of steamers by the aid of this power—of the boon it would be, for instance, if the public could travel in comfort, being lighted, warmed, and moved by this power on the underground railways. That would certainly be a remedy for the question which was agitating the public as to the offensive ventilators on the Embankment. They all knew that one of the great difficulties in dealing with this power had been its storage in a form which could be available at any moment, day or night. That difficulty had now been overcome. They also knew the difficulty that had existed as to its working with the greatest possible economy by means of natural forces. They all knew what a prolific source of power we had in water. This was a matter which was now receiving more attention than at any previous time. Now that electrical energy could be stored and used when wanted, it must be of the greatest importance to the whole community. He thought, for his own part, that the practical application of electrical accumulators was virtually unlimited, and step by step he believed that its utilisation would be secured. The chairman had referred to the lighting of the Pullman car on the Brighton Railway, and it might be interesting to them to know that whereas a year, in fact, six months, ago, it took seventy of the ordinary accumulators of the original pattern to light eighteen lamps, it took only thirty of their present pattern to light forty lamps, and their total weight was less than half that of the original battery. That would show them the great improvements which had been made in details, and he was sure that they would be continued, while carried on in such hands as those who were already engaged on the work.

The CHAIRMAN, in answer to Mr. Schiff, stated that they had heard a good deal about the Brush accumulator patent, and there had been some speculation concerning it. They had, however, consulted some of the best authorities, and they thought there was very little in it. If an attempt were made to work it here this Company would immediately step in and take steps to stop it. As far as they know, there was really no accumulator whatever, except their own, that was of any commercial value, and, as far as they could ascertain, other accumulators, which were talked about, were worthless commercially. He afterwards, in reply to Mr. Trench, read over the names of the directors, and stated that their meaning of the word royalty was this—there was a great deal of lead used in the accumulators, and they had bargained that those who made the accumulators should pay the Company £20 a ton. In the French agreement the amount taken was a *minimum*, and if they did not use the quantity of lead, they must, nevertheless, pay this Company the money. If the French company used the *minimum*, or below it, they would pay the Company £40,000 a year; if they used £10,000 worth of lead more, that surplus would go against the next year.

Mr. T. SUTHERLAND (Chairman of the Peninsular and Oriental Steam Navigation Company) testified to the successful working of the Company's accumulators at the offices of the Peninsular and Oriental Company, observing that they had been under his close personal observation during the last three months. The installation consisted of a small gas engine, and a small dynamo machine of Edison's and fifty accumulators, while the lighting circuits were, he believed, three or four in number. That was altogether about 280 incandescent lamps, of which the smallest was of 20 candle-power, while a considerable number were of even 40. The dynamo, which was a very efficient one, was sufficient to light only 60 of the lamps. They had tried several times to use the light direct from the dynamo, and although the lighting of the 60 lamps was so far satisfactory,

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it was accompanied by that somewhat distressing flickering which he thought was almost universally experienced in lighting taken from a dynamo machine of, comparatively speaking, small power. He should, therefore, for his own part, be exceedingly sorry to have to work the light in his own office direct from a dynamo such as he had seen used there. By means of the storage, however, they could light not merely the sixty lamps he had spoken of, but the 280 at one time, and so perfectly that they could not see a vibration or flicker of any kind. The difference, too, in the atmosphere as between lighting their offices by gas or electricity was so wonderful that if he had not experienced it himself he should not have credited it, the difference in point of comfort and salubrity being so marked.

The CHAIRMAN invited further discussion, but no gentleman rising to address the meeting he put the motion and declared it carried unanimously. He then moved the re-election of the retiring directors—Messrs. W. M. Bullivant, W. Ladd, and J. S. Sellon.

Mr. ROUPEL (shareholder) seconded the motion, and it was carried unanimously.

A discussion followed respecting the auditing of the accounts, and

Mr. TRENCH moved, and Mr. SCHIFF seconded, the election of Messrs. Deloitte, Dever, and Co., to act in conjunction with Mr. Alfred E. Jarvis.

Mr. NETTLEFOLD raised certain objections to the manner in which the profit and loss account had been drawn out on the present occasion. He objected most of all, he said, to the question of sales of patents being brought into profit and loss, as they really, he contended, belonged to capital. Their patents were their assets, and if they diminished their assets surely a decrease in their assets could in no sense be called profit. He thought, too, that the actual amount of cash received for patents should have been stated apart from the shares which had been received. No cash value could be put against the shares.

The CHAIRMAN thanked Mr. Nettlefold for his suggestion, but he had himself endeavoured to disabuse their minds of any idea that the shares represented so much. Whatever was distributed from the sale of patents would go towards reducing the capital of the Company. The Courts, in fact, would not allow them, even if they wished it, to divide as dividend money obtained from the sale of patents. He concluded by putting the resolution, and it was carried unanimously.

Two resolutions were afterwards passed, the first for making certain alterations in Articles 16, 54, 84, and 89, the proposed alteration of Article 44 being withdrawn. The certain resolution was as follows:—"That the contracts dated the 13th day of February, 1883, and made between La Force et La Lumiere and another, and the Electrical Power Storage Company (Limited); and the 16th day of February, 1883, made between the Electrical Power Storage Company (Limited) and the French Electrical Power Storage Company (Limited) be, and they are hereby approved and confirmed, and the directors are hereby authorised and instructed, notwithstanding anything contained in the Articles of Association, to accept surrenders of all, or any part, of the 36,000 fully paid shares of £2 each in this Company, mentioned in the said agreement of the 16th day of February, 1883. Provided always that nothing herein contained shall authorise the directors to accept any surrender of shares other than the surrenders hereby authorised."

A cordial vote of thanks to the chairman and directors terminated the proceedings.

THE GERMAN UNION TELEGRAPH AND TRUST COMPANY (LIMITED).

The twelfth ordinary general meeting of this Company was held on Wednesday, the 21st inst., at the offices, 66, Old Broad-street, E.C., Sir James Anderson in the chair.

Mr. WM. PAYTON (the secretary) read the notice convening the meeting, and the report of the directors was taken as read

The CHAIRMAN said: Gentlemen, before moving the adoption of the report, I will make a few remarks, especially as this is Easter time, and there is not a very large number of shareholders here, and the report will go to them of anything that may be said. Last year the new cable from Valentia to Greitseil was only four days laid at the time of our meeting; therefore, we had nothing to say but to express a hope that it would be remunerative. I am very glad to say that after twelve months experience I think it even exceeds the expectations that any of us had at that time. Notwithstanding the fact that we had our main cable broken between Emden and Lowestoft for three months, we still have managed to pay within one per cent. of our last year's dividend, and also to pay the five per cent. upon the new capital for the line from Valentia to Greitseil. Really I hardly expected such a fortunate state of affairs, seeing the length of time that that cable remained broken. Fortunately, however, we were in the hands of the Telegraph Construction and Maintenance Company, who manufactured the cable for us of a length of about thirty-five or, perhaps, forty miles. About twenty-five miles of the cable were not required; but whatever the length was they have not charged us with it, but have taken it off our hands with the chance of selling it as time goes on, so that we only had to pay for the cable used. The repairs cost altogether £7,000, and, putting by the usual 10 per cent. of reserve for renewal fund, and an additional 5 per cent. which was sanctioned by the shareholders until such time as the £7,000 is made up, or put back again to the renewal fund, we are still in a position to pay £5 5s. odd per cent., and the reserve stands now, I am happy to say, at something like £29,000. In fact, it is a very good reserve, but not too much considering that our cable is a very long one, from Valentia to Greitseil, crosses a good many other cables, and may cost something for repair as time goes on; but I do not think we can very well complain. Although the tariff has been raised since last year from 1s. a word to 2s., we have the anomalous experience that we have actually made an increase of traffic—an increase of the number of messages, as well as an increase in revenue, with a higher tariff. I think that is the first experience of the kind we have ever had, and it can only be accounted for by the fact of our having supplied the want of Germany for more direct communication with America, and possibly by the increase of commercial intercourse. It is a very curious experience altogether, the effect of tariff, and in the Anglo-American and Atlantic Cable Companies, as you are aware, the tariff has been raised from one shilling to two shillings within this time we are speaking of, and the experience there has been that the revenue has increased 70 per cent., and the number of words has only decreased 17 per cent., showing, I think, that the code messages have been so scientifically arranged that merchants cannot now reduce the number of words in any of their messages any further, and that a cheap tariff does not induce them to send any more words, because they have arrived at such perfection in the coding of telegrams that they can express all their wants in a few words. I think we are getting at the bottom of the difficulty or the obstacle with the merchants' code telegrams against the revenue of the telegraph companies. The companies never have stood in the way, but were the first to inaugurate the use of code words for expressing commercial matters, and we are at the point I hope where we may reap our reward by seeing a gradual increase, as the merchants have learned to express their wants with the minimum of words. Now, gentlemen, I think that is pretty much all that remains that the report calls upon me to move. I have nothing to report of a serious character, excepting, perhaps, the fact that our cable house, as we call it, at Lowestoft, has been washed away by the storms and high tides, but that is not a very expensive matter at the worst, and steps, of course, are being taken to put it right again. We are not losing any traffic in consequence of the washing away of the house. I have now, therefore, to move the adoption of the report:—"That the report and accounts of the directors for the year ending 31st December, 1832, submitted to this meeting, be, and they are hereby received and adopted, and that a dividend of 4s. 10d. per share, free of income-tax, making, with the previous distribution of 5s. 9d. per share, a total dividend for the year of 10s. 7d., or at the rate of £5 5s. 10d. per cent. per annum be now declared, to be payable on and after this date."

Mr. HERMANN GUSTAV ERICHSEN: I beg to second it.

The motion was put and carried unanimously, and without discussion.

Sir JAMES ANDERSON, the director who retired by rotation, having been re-elected,

Mr. FULLER said he had to bring to the notice of the shareholders a resolution which he felt sure they would cordially adopt when they were aware of its nature. The sound condition which this Company had attained was due entirely to the management and foresight shown by the directors in the arrangements they had made, more especially with regard to those cables which were laid during the past year. He could speak from personal knowledge of the value of the cable by which they connected their own cables with the Atlantic system, and he had much pleasure, therefore, in bringing to their notice the following resolution:—"That the remuneration of the directors for the year ending December 31, 1882, and in future, be at the rate of £400 per annum."

A SHAREHOLDER seconded the motion, which was carried unanimously.

On the motion of Mr. HENDERSON, Mr. Henry Dever was re-appointed auditor; after which a vote of thanks to the chairman and directors terminated the proceedings.

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

Report of the directors for the half year ended 31st December, 1882, to be presented at the general meeting of shareholders, to be held on Saturday, 31st March, 1883:—The annexed accounts for the half year ended 31st December, 1882, show a balance to the credit of profit and loss of £7,056 17s. 9d. The receipts, although somewhat inferior to those of the last half year, are in excess of those for the corresponding period of 1881. In the early part of December a fault of insulation occurred in the shore-end of the Bilbao cable near the Lizard, but it did not interfere with the communication; it was successfully extracted in January. The Barcelona cable was broken down from the 8th to the 31st December. It was satisfactorily and economically repaired, and has since been in excellent working order. The cost of these repairs, £751 9s. 5d., was paid out of the revenue of the half year. The directors informed the shareholders, by a circular dated 30th November last, that they had concluded an arrangement with the Eastern Telegraph Company to work the direct traffic between England and Spain on the joint-purse system. This arrangement came into force on the 1st December, and has proved satisfactory, securing to this Company a revenue during the interruption of the Bilbao cable. After paying the dividend on the Preference shares, amounting to £2,921 10s., and appropriating £200 to the reduction of the preliminary expenses account, there remains a balance of £3,935 17s. 9d. The directors deeply regret that they cannot recommend the payment of a dividend on the Ordinary shares, feeling the necessity of carrying the whole of this balance to the reserve fund, owing to the unfortunate interruptions of the Bilbao cable since the 1st January last, the repairs of which have to be provided for. The dividend warrants on the Preference shares will be payable on the 2nd April. Mr. Ettinger and Mr. Scott are the directors who retire by rotation, and, being eligible, offer themselves for re-election. Mr. Herbert R. Duke is eligible as auditor for the present year.

TRAFFIC RECEIPTS FOR FEBRUARY, 1883.

COMPANIES.	Feb., 1883.	Feb., 1882.	Incrse.	Decrs
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company.....	—	—	—	—
Cuba Submarine Company	3,900	3,271	629	—
Direct Spanish Telegraph Company	1,544	2,109	—	565
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	46,667	44,046	2,621	—
Eastern Extension Telegraph Company	29,391	27,473	1,918	—
Great Northern Telegraph Company	17,800	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

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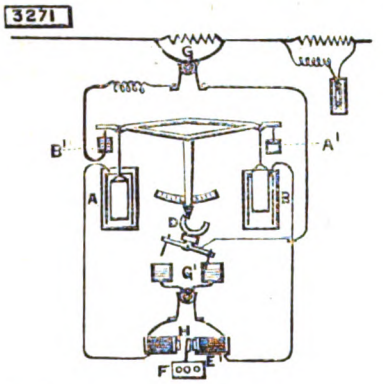
RECENT INVENTIONS.

ABSTRACT OF SPECIFICATIONS.

3271. Electrical Meters, *T. J. Handford, Southampton-buildings.*—*10th July*, 1882.—(*A communication from T. A. Edison, Menlo Park, New Jersey, U.S.*). 6*d*.

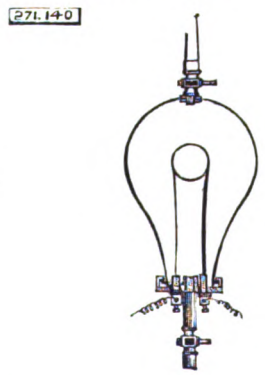
The object of this invention is the automatic registering of the electrical energy consumed in a circuit. This is accomplished, as shown in the illustration, by two plates of two cells, one from each, being suspended to a beam oscillating upon its centre. The cells are arranged in a shunt circuit around resistance placed in the line of one of the main conductors of a house circuit, and have connected with them a circuit-making-and-breaking device operated by the beam, by which the current of the shunt always passes through the



cell, having its electrodes elevated or depressed according to whether the meter is acting, by depositing upon or stripping from the suspended electrodes. At the end of each month the direction of the current through the cells and the connections of the circuit controller are reversed, and the suspended electrodes become the anodes of the cells if they have been acting as the cathodes during the previous month, or *vice versâ*. Referring to the illustration, A and B are the cells, A^1 and B^1 a dashpot and mercury cup respectively; D is a circuit controller, with arms provided with points dipping into mercury cups; E E^1 are electro-magnets acting upon armature lever H, the movement of which works F, the register; G G^1 are hand-operated current reversers.

271,140. Combined Electric Light and Gas Burner, *William A. Shaw, Brooklyn, N.Y.*—*Filed May 3rd*, 1882.

Claim.—The combination substantially as hereinbefore set forth of the gas conduit or chamber,



the incandescent electric conductor enclosed within said conduit, and the illuminating gas burner attached to the said conduit.

3244. Incandescing Electric Lamps, *T. J. Handford, Southampton-buildings, 8th July*, 1882.—(*A communication from C. A. Van Cleve, Metuchen, Middlesex County, New Jersey, U.S.*)—(*Void.*) 2*d*.

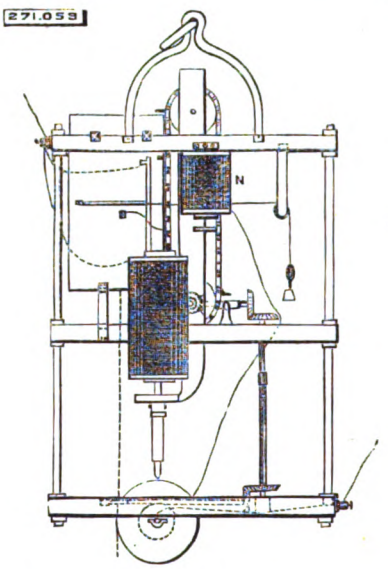
To remove the aqueous vapour remaining in the globes of incandescing lamps after being exhausted of air by the mercury pump, the inventor introduces and seals in the globe phosphorus anhydride or some such compounds.

3232. Electric Clocks, *J. P. A. Schlaefli, Soleure, Switzerland.*—*7th July*, 1882. 6*d*.

This relates to an improved secondary electric clock to be actuated by a weight raised periodically by a current sent at frequent intervals from a central station.

271,059. Magazine Electric Lamp, *Alenza T. Gifford, Providence, R.I.*—*Filed January 12th*, 1882.

Claim.—(1) In an electric arc lamp, the combination with the magazine provided with devices for discharging single pencils successively therefrom, of the endless chain provided with projections for striking the pencils discharged and forcing them toward the opposite electrode, and suitable devices for operating said chain automatically as the result of increased resistance in the lamp circuit, substantially as described. (2) The combination with the magazine provided with the automatically closing doors and automatic means for discharging the pencils through the doorway of the endless chain provided with means for opening said doors and driving the discharged pencils forward longitudinally, substantially as described. (3) The magazine provided with the automatically closing doors, means for automatically discharging the pencils, and a guide for a single pencil outside of said doors, substantially as described. (4) The combination with the maga-



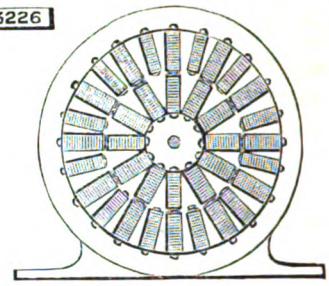
zine provided with a guide for single pencils, and with automatically closing doors, of the travelling chain provided with means for driving the pencils longitudinally, and automatic devices for opening the doors to permit a fresh pencil to pass, substantially as described. (5) In an electric arc lamp, the combination, with the electro-magnets for lifting a carbon pencil from an opposite electrode to establish the arc, of an electro-magnet of higher resistance in a derived circuit around such magnets, a feed operating magnet in a shunt circuit, and shunting devices operated by said magnet of higher resistance for shunting the main current through said feed operating magnet, substantially as described. (6) The combination with the electro-magnets N^1, arranged in a shunt circuit for operating the pencil feed and the electro-magnet N of higher resistance, arranged in a derived circuit of the levers M and M^1 carrying armatures for such magnets respectively, a circuit breaking or shunting device operated by the first-named lever to direct the main current over the coil of magnet N^1, and means for restoring said shunting device to its normal condition by the action of the lever M^1, substantially as described.

3172. Voltaic Batteries, *J. Imray, Chancery-lane.*—*5th July*, 1882.—(*A communication from P. Jablochkoff, Paris.*) 6*d*.

This consists in the employment of sodium or potassium as the negative element in a battery, the voltaic action being by this means produced by air alone, in place of the acid usually employed. The other element is either carbon, or spongy platinum, or metal gauze, the porosity of which is necessary to admit air to act on the oxidisable metal, a porous material, such as thin paper, being interposed between the two elements.

3226. An Improved Electro-magnetic Motor *E. Toynbee, Willesden.*—*7th July*, 1882. 6*d*.

This motor consists of a series of concentric, parallel, revolving, and stationary electro-magnets, so arranged that the whole shall form one or more continuous rings of magnetic poles, enclosing the whole, or nearly so, of the magnetic lines



of force. The whole of the revolving or stationary magnets are commutated at each segment of the circle, thus producing a maximum and uniformly continuous rotary motion. Great velocity can be obtained, the inventor states, with no heating, and without much wear and tear. The apparatus is shown in end view in the accompanying illustration.

3171. Apparatus for Governing Marine Engines by Electricity, *W. W. Girdwoods, Poplar.*—*5th July*, 1882. 6*d*.

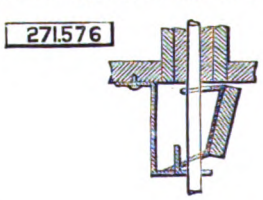
This relates to a combination of a float placed in a tube close to the propeller of a steamship and connected by chains with a wheel placed in close proximity to an electro-magnet, the armature of which is connected with the throttle valve of the engine to be controlled. The action of the wheel causes the circuit of the electro-magnet to be broken or closed, and the armature attracted or not, according to whether the float descends or ascends, owing to the motion of the sea. When the float descends it closes the circuit, and by means of the electro-magnet, armature, and gearing, the throttle valve, but when it ascends the circuit is broken and the valve opened.

3255. Incandescent Electric Lamps, *J. H. Gardiner, Camberwell.*—*8th July*, 1882. 6*d*.

This relates to a blow lamp for constructing the glass globes of incandescent lamps, by means of which either a large flame, covering a wide area, or a pointed flame, to strike one spot only, can be obtained at will, thus obviating the use of two such lamps; also to a new pump for exhausting the globes of air, which operates by the continual reproduction of the Toricellian vacuum; and lastly, to a new method of mounting the lamps in sockets for use.

271,576. Electric Arc Lamp. *Joseph R. Finney, Pittsburg, Pa.*—*Filed November 8th*, 1882.

Claim.—(1) The combination in an electric arc lamp, of a hollow electro-magnet, through which the feed rod passes, a pivotted armature arranged at the side of the feed rod, and a perforated plate or ring attached diagonally to the armature and encircling the feed rod, substantially as and for the purposes described. (2) The combination in an electric arc lamp, of an electro-magnet, a feed rod, a pivotted armature arranged at the side of the feed rod and beyond the vertical plane of the core of the magnet, and a perforated plate or ring



attached diagonally to the armature and encircling the feed rod, substantially as and for the purposes described. (3) The combination in an electric arc lamp of an electro-magnet, an armature capable of an axial movement, and having a slotted projection to encircle the feed rod to keep it from falling, and a circular clamp to grasp the feed rod, and a stirrup or support to sustain the armature, substantially as and for the purposes described. (4) The combination in an electric arc lamp of an electro-magnet, an armature capable of a radial and an axial movement, and a stirrup or support for the armature, having a guide pin to guide the armature in its movements, substantially as and for the purposes described.

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SLIP

THE MAXIM-WESTON ELECTRIC COMPANY.—Mr. T. R. Comyn has been appointed secretary of this company in place of Mr. F. H. Landon, resigned.

BRUSH MIDLAND ELECTRIC LIGHT AND POWER COMPANY.—The offices of this company have been removed from 31, Lombard-street, to 4, Great Winchester-street-buildings, E.C.

ELECTRIC LIGHTING IN NEW ZEALAND.—The New Zealand Electric Light Company are to light Lyttelton with sixteen Brush lights, equal to 3,200 candles, says the *Colonies and India*.

TRINIDAD.—The latest news from Trinidad states that the telegraph steamers the "Duchess of Marlborough" and "Grappler" had been engaged in repairing the cables between Trinidad and Grenada, and Grenada and St. Vincent.

TENDERS WANTED FOR ELECTRIC LIGHTING.—The Committee of the Huddersfield Fine Art and Industrial Exhibition are inviting tenders for lighting portions of the exhibition building by electric light. Plans and particulars can be had of Mr. A. Keen, the secretary.

THE RATING OF WIRES.—The Postmaster-General was summoned at the Willenhall (Staffs.) Police Court a few days since for non-payment of poor rates, the unpaid rate being in respect of telegraph poles and wires within the township. The usual order for payment was made.

MR. LEVER'S PREMIUM FOR A MINERS' LAMP.—The Council of the Society of Arts having been requested by Mr. Ellis Lever to appoint one of the judges to award the prize of £500, which he has offered for a miners' safety lamp, have complied by appointing Professor F. A. Abel, C.B., F.R.S.

TELEGRAPH WIRE, &c., WANTED.—The Lancashire and Yorkshire Railway Company are inviting tenders for the supply of telegraph fittings, wire, tin, zinc, &c., for the next half year. Further particulars and forms of tender can be had at the Stores Department, Miles Platting, near Manchester. Tenders must be lodged with the secretary, Hunt's Bank, Manchester, by 10 a.m. on April 9.

THE ELECTRIC LIGHTING ACT.—Major R. Y. Armstrong, of the Royal Engineers, at present stationed at Chatham, has been appointed by the Board of Trade to superintend the carrying out the provisions of the Electric Lighting Act of last session. Captain P. Cardew, R.E., has been appointed instructor in telegraphy at the School of Military Engineering, Chatham, in the place of Major Armstrong.

ELECTRIC LIGHTING IN SEWERS.—Six Brush lamps were used to light a portion of the sewer which distributes its contents over the market gardens of Gennevilliers, Paris, up to a recent date, when, however, the floods put a stop to this mode of lighting. Our contemporary, *L'Electricité*, gives an illustration of the huge sewer, as lighted by the above lamps, and expresses the hope that the Municipal Council of Paris will continue this means of illumination.

ELECTRIC LIGHTING IN DUNDEE.—A correspondent writes to say that the paragraph in our last issue referring to the adoption of the Brush light in Dundee is incorrect in some particulars. According to him the arrangement completed between the Corporation and the Brush Company of Scotland is that they have withdrawn their application for a provisional order and allowed the company to proceed unopposed. The name of the superintending electrician also should be Martin, not Morton.

CITY AND GUILDS OF LONDON INSTITUTE.—We notice that the summer term of the day school of this institute commences for new students on the 12th April. Particulars as to the fees, &c., can be had at the Technical College, Tabernacle-row, E.C. The 1883 Technological Examinations will take place on the evening of the 30th May, at 7. A programme, with a syllabus of each subject and last year's papers, can be had of Mr. P. Magnus, at the central office of the Institute, Gresham College, E.C.

THE POSTMASTER-GENERAL AND THE TELEGRAPHISTS.—Mr. Fawcett has issued the following special notice to the telegraphists: — "The Postmaster-General observes that attempts are being made to press him to re-open and revise the question of the re-organisation of the telegraph service, which, after the most attentive consideration, and at great cost to the taxpayer, he settled in 1881. He thinks it right to inform the staff that he has no intention of re-opening the question involved in that settlement."

AN ARSENAL STRUCK BY LIGHTNING.—A telegram from Vienna, dated March 23, says that "on the 10th inst. the arsenal of Cettinje was struck by lightning. The building is of very primitive construction, and contained considerable stores of gunpowder and ammunition. The central portion was blown up. Some brave men, however, at the risk of instantaneous destruction, threw out the chests of powder and ammunition into the snow, whence the men and women who had collected carried them to a safe distance."

A WEST END LIGHTING STATION.—We are enabled to state that the Swan United Electric Light Company are sufficiently confident of obtaining their provisional order for lighting a large district in the west of London, of which the Victoria Railway Station may roughly be taken as the centre, that they have commenced to erect the necessary buildings. These are so far forward that they have reached the first floor level. Engines and boilers for the supply of 1,000 horse-power have been ordered for this station, and are now approaching completion.

ELECTRIC LIGHTING IN THE CITY.—A report on the works carried out by the Commissioners of Sewers during last year has just been issued by their engineer, Colonel Haywood, who is its compiler, and includes, amongst other matters, electric lighting. It gives a history of electric lighting in the City during 1881 and last year. As the substance of it has already appeared in these columns at different dates, and as our space is already far too small for the matter awaiting insertion, we shall content ourselves with notifying its publication to our readers.

ELECTRIC LIGHTING FOR VIENNA.—A telegram to the *Standard*, dated Vienna, Wednesday night, says:—"The Vienna Town Council, at its sitting to-day, considered the proposal of the Anglo-Austrian Brush Company to supply Vienna with arc (Brush system), and incandescent lights on the Lane-Fox system, and with electric motive power by laying down cables throughout the entire city. In return for this the company demands the exclusive right to supply the city with electric lighting for a period of fifty years. To this long term there is a strong opposition. The council has not yet come to a decision, but I believe that the monopoly desired by the company will not be granted."

IRIDIUM PLATING.—Mr. W. L. Dudley has announced before the Ohio Mechanics' Institute that the problem of electro-plating with iridium has been solved by employing a

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suitable solution of the metal and properly regulating the electric current. The solution (says the *Engineering and Mining Journal* of New York) is kept at uniform strength by using a plate of iridium as the anode. The metal is deposited in the reguline state, and takes a good polish. A buffing-wheel that will grind off nickel plating in a few moments only serves to polish the iridium. Thin platinum foil, coated with iridium, retains its flexibility; and if the coating is not too thick, it will not readily scale off.

Electric Lighting at the Mansion House.—Some changes have been made in the arrangement of the engines and machines connected with this installation. The whole was removed a few days since from the basement, where it was set up at first, to one of the lower passages beneath. This work necessitated no small amount of care and skill, but was successfully carried out in a very short time by the contractors, Messrs. R. E. Crompton and Co. Advantage has been taken of the removal to erect two Otto gas engines in place of the one hitherto in use, so that all chance of a total breakdown might be removed. The engines are so arranged that if one stopped the other could be set going with scarcely any delay.

The Law Courts.—The lighting of the Law Courts is now complete throughout, with the exception of a few trifling fittings. Twenty-two courts, the whole of the bar corridors, and staircases, approaches, robing and refreshment rooms are lighted by means of Swan lamps. The central hall has six Crompton arc lamps of the latest pattern, but at present it is not found necessary to use these on account of the light afternoons and evenings. Some of the courts, however, are so dark on a cloudy afternoon that steam is always kept up and light supplied whenever required. As our readers are well aware, the whole of this work has been carried out by Messrs. R. E. Crompton and Co., engineers to the Swan United Electric Light Company.

The Telephone in London.—In an annual article (vide *The Electrician* for January 13, p. 205) we gave some statistics showing the progress made by the United Telephone Company during last year. At the time we wrote the total number of subscribers to the company's exchange was 2,247. On the 27th of January it had risen to 2,442, on the 28th of February to 2,541, and on the 28th of March, that is Wednesday last, the total number was 2,606. The number of calls per day in July last averaged 14,000. If this figure be compared with the following it will be seen that considerable progress has been made. Thus, on the 14th of March this year the number of calls was 18,879; on the 15th, 18,910; on the 16th, 19,948; (the 17th, being a Saturday, cannot be compared with ordinary days); on the 19th, 19,654; on the 20th, 19,958; on the 21st, 19,948; and on the 22nd, 20,715. For these figures we are indebted to the courtesy of the company.

Electric Lighting at Oxford.—An installation of six Pilsen arc lamps and 100 incandescent lamps has just been completed on the premises of the Union Society, Oxford. The Pilsen lamps are used for lighting the debating hall, the library, the smoking room, and outside, while the incandescent are placed in the library, entrance hall, telegraphic room, smoking room, and general offices. The power is derived from an Otto gas engine, provided with silencing chamber. The dynamo machines are placed in a house specially constructed in the grounds of the Union Society, and are fitted with the usual electrical apparatus. The work has been carried out by the Pilsen, Joel, and General Electric Light Company, of London. The fittings are plain and substantial, and afford every facility for regulating the lamps. No doubt the members will appreciate the advantage of the pure atmosphere afforded by the electric light as compared with gas.

Our Parisian Confreres.—*L'Electricité* informs us that the first of a series of monthly dinners, to which all interested in electricity were invited, took place on the 21st March, under the presidency of M. Cochery, Minister of Posts and Telegraphs, at the Café Durand, Place de la Madeleine, Paris. The initiative in this case is, we are told, due to M. le Comte Hallez d'Arros, the editor of *L'Electricité*. The interior of the café was lighted by means of 82 Swan lamps, the current being supplied by accumulators furnished by the French Electrical Power Storage Co. These accumulators also fed two arc lamps placed in the street outside the café. The total number of guests was sixty, many of whose names are almost as familiar here as they are in Paris. Speeches were made after the dinner by M. Cochery, M. Berger, M. le Comte d'Arros, and others. It was announced that in future a similar *réunion* of electricians would take place on the 21st of each month.

Electric Light in Lahore, India.—The installation at the Scinde, Punjaub, and Delhi Railway Station consists of:—Two platforms, four lights each, = eight; one outside platform, two lights, = two; goods yard, three lights, = three; two booking offices, one light each, = two; and front entrance to street, one; or a total of sixteen lights. The circuit is nearly two miles long. The power is supplied by an old locomotive engine, which is also used for driving the machinery of the company's printing presses. Coal being very expensive in the Punjaub wood only is used as fuel. The Scinde, Punjaub, and Delhi Railway have purchased the plant, owing to the success of the first trial, and are about to purchase more. Mr. E. W. Lancaster carried out the work for the Eastern Electric Light and Power Company of Bombay. It is expected that the well-known Golden Temple of Umritsar, India, will soon be lighted by the same system. A subscription is being got up by various native princes and others for the purchase of a plant. This will be the first temple or native place of worship lighted by electricity, or by Christians. All leather, grease, and other ingredients, &c., will be avoided so as not to violate native caste.

Long Distance Telephony.—A telegram from the *Standard's* New York correspondent appeared in a recent issue of that paper, giving an account of a telephone trial which took place between New York and Chicago on the 25th inst., over a distance of 1,000 miles. The telegram went on to say: "Previously the longest distance over which a message had been sent was 700 miles, between New York and Cleveland. The present result is not due solely to the telephone, although that possesses some novelty, but is mainly due to a novelty in the conductor; this consisted of a steel wire core copper plated, the electrical resistance of which to Chicago was only 1,522 ohms against upwards of 15,000 ohms, the average resistance of ordinary iron telephone wire." All this may or may not be true. Time will show. In the meantime, and until further details have come to hand, we advise our readers not to swallow too much of the information given above. As far as telephoning over 1,000 miles of wire goes, the Americans have been beaten by Australia. We have it on the best authority that 1,500 miles and more have been telephoned over in that country, and speech distinctly heard. Whether the success of the trial in America really did lay with the wire used time alone can show.

Electric Lighting and the Board of Trade.—The

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Chelsea Vestry have addressed a letter to the Board of Trade, which contains the following:—"As regards the main features of the Chelsea Electric Lighting order, the vestry beg to submit that, in accordance with your suggestion, they have discussed the same with Mr. Moulton, and have practically agreed on the proposed area of supply. As to any further points upon which the promoters and the vestry may differ, it may be convenient to reduce them to writing and submit them to the Board of Trade for final decision. In the vestry's letter to the Board of Trade on their objections to the Metropolitan Brush Provisional Order (clause 3, part B), it was suggested 'that, whenever practicable, a distributing main should be laid under the footway on each side of the street, so as to avoid the interruption of traffic and breaking up of streets which would be occasioned if the lines were laid under the roadway.' This point, the vestry have reason to believe, is also practically agreed on. The vestry suggest that the Board of Trade should add a model clause to this effect, so that, wherever practicable, other districts may secure the benefit of its adoption, whereby uniformity will be obtained." The Board, we believe, have agreed to modify some clauses so as to meet the views of the Chelsea Vestry and other critics; and it is stated that the amended clauses will be ready for the public on Monday next.

The Crystal Palace Exhibition.—This exhibition is still being added to by fresh exhibitors. Amongst the latest to appear are Messrs. Crossley Brothers, who are to light up the Italian courts with Swan lamps. Bürgin machines, supplied by Messrs. Crompton, will be used. These machines are fitted with steel fly-wheels keyed on to the dynamo spindle close to the pulley. The surface speed of these fly-wheels when the machine is running at 1,600 revolutions is nearly two miles per minute. They are said to entirely prevent the oscillation of the light, which is usually considered inseparable from the use of gas engines as motors. The Gülcher Electric Light Company, in combination with Messrs. Defries, art metal workers, have also completed their exhibit now. This company lights the mediæval courts by means of Crookes's incandescent lamps and Gülcher arc lights. The incandescent lamps are fitted into some most elegant and elaborate pendants, brackets, &c., exhibited by Messrs. Defries, the effect of which is extremely pretty, and calculated to show off incandescent lamps to the best possible advantage. The Gülcher exhibit is interesting from the fact that both arc and incandescent lamps are run off the same machine. We shall have more to say concerning this combined exhibit in a future number. Another exhibitor is Mr. Trotter, who shows his system of distributing light by means of glass globes or lanterns, the sides of which have grooves cut at particular angles so as to distribute as much light as possible. Mr. Trotter has, we hear, engaged a well known electrician, to report on his system. In the meantime, however, a very good idea of its merits can be obtained at the palace. Of miscellaneous exhibits Mr. J. Sax has undoubtedly the best collection. We shall refer to these and other apparatus as our space permits.

The Chemistry of Storage Batteries.—A paper on this subject was recently read before the Physical Society by Dr. E. Frankland. The first part dealt with the chemical changes occurring in the charging and discharging of storage batteries. Proof was given that occluded gases play, practically, no part in the phenomena of the storage cell. It was shown that the active material on the plates is lead sulphate, and that the initial action in charging is the electrolysis of sulphuric acid into hydrogen, sulphuric anhydride, and oxygen. The hydrogen decomposes the lead sulphate on the negative plate into spongy lead and sulphuric acid, whilst the oxygen decomposes the lead sulphate on the positive plate into lead peroxide and sulphuric anhydride. All sulphuric anhydride is at once converted into sulphuric acid. In discharging the initial action is again the electrolysis of sulphuric acid, which restores the coating of the two plates to its original condition of lead sulphate. The second part of the paper treated of the chemical estimation of the charge in a storage cell. This is founded upon the reactions described in the first part. As the charging of a cell is attended with the liberation of sulphuric acid, and its discharge with the abstraction of this acid from the liquid contents of the cell, it is only necessary to ascertain the specific gravity and consequent strength of the acid to determine the amount of charge in a cell at any given moment—provided, of course, that the specific gravity of the acid in the charged and uncharged condition of the cell be previously known. A suitable space for a small hydrometer in a storage cell could easily be contrived, and, if the graduated stem were made to rise above the cover, the amount of stored energy could be seen at a glance. The author stated that in the case of the cell with which he had experimented, each increase of ·005 in the specific gravity of the dilute acid meant a storage of available energy equal to twenty amperes of current for one hour.

Electric Lighting in Theatres.—"People in Paris do not seem to trouble themselves much concerning the propriety of lighting their theatres by means of electricity," says the *Révue Industrielle*. "Some months ago this question was to the fore, and the experiments carried out at the Théatre des Varietés gave rise to an enthusiasm which has now cooled down. It is suggested that incandescent gas lamps should be introduced at the opera, but the matter is of sufficient importance to think twice about it; and, again, its consideration has been entrusted to an official committee, which does not promise us a quick solution. So it happens that we must go abroad for our facts. In London, the Savoy Theatre, in Brünn, the Municipal Theatre, are both lighted by electricity, which has also just been adopted at the Parc Theatre in Brussels. Here the Edison system is in use, and the Brussels press is pleased to notice that the light is soft, regular, adaptable to any circumstances, and does not overheat the air or pollute it. The installation comprises 250 to 300 lamps, to judge from the fact that the dynamo requires 35 h.-p. Under these conditions competition with gas is possible, although the net cost of one centime per hour per lamp seems to us a little too low, depreciation and interest put aside. As a rule we must reckon that electric lighting on the incandescent system will cost, everything included, for an installation of 4 to 500 lamps of 2 carcels from 80 to 100 francs per lamp, and that the total net cost for an average of 500 hours per year will not be much lower than 4 centimes per lamp per hour, or 2 centimes per carcel per hour (a carcel = 9·6 English candles). Admitting that 105 litres of gas correspond to a carcel per hour (a litre = 61·0254 cubic inches), and this consumption is exceeded in practice, it would be advantageous to employ electricity so long as gas cost more than 16 centimes per cubic metre. Theatres, shops, and workshops are the only places that can hope to realise this economy, whether it be on account of the large number of burners they need, or the facilities for erecting the lamps and machines when the motive power is already at hand. The introduction of incandescent lamps into ordinary houses seems to us to be dependent upon the progress made in the construction of accumulators and primary batteries. The gas companies need not, therefore, disquiet themselves." When, however, two or three more stations like

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Edison's, in New York, have got to work, it is possible that our excellent contemporary may change its mind. We certainly do not think that any progress that may be made in the construction of primary batteries is likely to have much effect upon the question of the introduction of the incandescent light into private houses.

Remarkable Electrical Discovery.—Under this head the following paragraph appeared in *The Times* of the 24th inst., and has since gone the round of most English journals: "Applications of electricity are not only making rapid progress in every part of Europe, but also in the southern hemisphere. There come, indeed, from Otago, New Zealand, details of an invention as marvellous as any yet recorded in the annals of electrical science. The Rev. Mr. Gilbert, of Christ Church, in a recent address, told his audience that it was now proved to be possible to convey, by means of electricity, vibrations of light—not only to speak with your distant friend, but actually to see him. The electroscope—the name of the instrument which enabled to do this—was the very latest scientific discovery, and to Dr. Guidrah, of Victoria, belonged the proud distinction of being its inventor and perfecter. Mr. Gilbert stated that a trial of this wonderful instrument had taken place at Melbourne, in the presence of some forty scientific and public men, and that it had been a great success. Sitting in a dark room, they saw projected on a large disc of white burnished metal the race course at Flemington, with its myriad of active beings. Minute details stood out with perfect fidelity to the original, and as they looked at the wonderful picture through binocular glasses, it was difficult to imagine that they were not actually on the course itself, and moving among those whose actions they could so completely scan." In *The Electrician* for the 5th of February, 1881 (Vol. VI., p. 141), under the title of "The Telectroscope," we gave an account of an invention of M. Senlecq, of Ardres, in France, to which he had given that name. It may not be out of place to quote here the first few lines of that article. They are as follow:—"This apparatus, which is intended to transmit to a distance through a telegraphic wire pictures taken on the plate of a camera, was invented in the early part of 1877 by M. Senlecq, of Ardres. A description of the first specification submitted by M. Senlecq to M. du Moncel, member of the Paris Academy of Sciences, appeared in all the continental and American scientific journals. Since then the apparatus has everywhere occupied the attention of prominent electricians, who have striven to improve on it. Amongst these we may mention MM. Ayrton and Perry, Sawyer (of New York), Sargent (of Philadelphia), Brown (of London), Carey (of Boston), Tighe (of Pittsburgh), and Graham Bell himself." In March, 1881, Professor Perry described his own and Professor Ayrton's methods of carrying this invention out, in the Cantor Lectures which he was then delivering at the Society of Arts. These lectures will also be found in Vol. VI. of *The Electrician*. Perhaps the Rev. Mr. Gilbert, of Christ Church, New Zealand, would change his mind about "the very latest scientific discovery," of which, according to him, Dr. Guidrah is the "inventor and perfecter," were he to read the articles mentioned above, for we must, perforce, conclude that he is unaware of their existence.

Electrical Transmission of Power.—Last week a paper on the above subject was read by Mr. W. M'Whirter, A.S.T.E., at Barrow-in-Furness, under the auspices of a local debating society. In the course of his paper Mr. M'Whirter gave some calculations as to the power available at the present time within a short distance of Barrow. He said:—"Through the kindness of Mr. W. B. Kendal, I am able to lay some facts before you in relation to the water power running to waste within a reasonable distance of Barrow. The height of Windermere is 134ft. above the sea level, and the average discharge from the lake is about 18,000 c.f. per minute; within three-quarters of a mile of foot of lake, a head of 25ft. can easily be obtained, at this point the theoretical h.-p., would be 850 or, say, 500 effective. Before reaching the sea, however, a total working head of fully 100ft. can be obtained, and this, taking the same ratio as above for effective work, would give us over 2,000 h.-p. The distance of the Lake Foot from Barrow would not be more than 20 miles, and a copper conductor of $\frac{1}{4}$ might easily carry the current; of course a wire would be required there and back of a total length of, say 40 miles. I estimate that such a circuit could be erected on overhead poles at about £100 per mile. If it were actually necessary to put the wires underground, then the cost would be, at least, five times as much, or, say, £4,000 for open wires, and £20,000 for cables laid underground. At the above distance of the 2,000 h.-p., put into the circuit using an E.M.F. of 80,000 volts, there would be lost in transmission only 17 h.-p. Should the amount of power available at Windermere not satisfy you, then there are other rivers to fall back upon, all within reasonable distances. The Kent has the same average discharge as the Leven, and the Lune has about four times that amount. Why, however, the question may be asked, go to Windermere. Is there no place more convenient? The area of the Cavendish Dock is 6,000,000 square feet, with an average depth of about 10ft., the height of the top water being 23ft. above low water channel. Now, supposing we take the available fall as 10ft., which is certainly very low, we would, from this source alone, running out once per day, obtain a theoretical value of 1,800 horse-power, or, say, 1,200 actual; but if we could run it out twice per day, and also make the incoming current do work, then we can easily have over 4,000 horse-power available. This alone would, I believe, drive all the machinery in Barrow. But further, the width of Walney Channel, opposite Piel, is 800 yards, with a sectional area of 40,000 square feet; the average rise of the tide is 24ft., with a velocity of 400ft. per minute. I have been asked if 50,000 horse-power can be got at this place. For my own part I see no difficulty in recovering much more than that, and I, for one, am sanguine that the day is not far distant when the great natural forces, such as I have just mentioned, will all be utilised, and when that time comes I feel sure that Barrow will not be left behind in the van."

The South Eastern and Provincial Brush Companies.—A circular has been addressed to the shareholders in the above electric light companies by their manager, Mr. George Offor, from which we quote the following paragraphs. After referring to the provisional orders for which both companies have applied, and which have been recorded in *The Electrician*, Mr. Offor goes on to say:—"The Town Council of Colchester having consented to the grant of a license from the Board of Trade, arrangements have been made for supplying electricity to the residents in High-street and Head-street—which comprise two of the most important thoroughfares of the town—a lighting station has been fitted up with the necessary machinery, dynamo machines, &c., and several shops, besides the Red Lion Hotel, have already been supplied with incandescent lamps, and your directors hope before next winter to complete in this town the most important installation of electric lighting yet undertaken in this country." We may remark that this paragraph refers to the South Eastern Company only. What follows has reference,

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however, to both companies, and to the patents in which they have secured an interest. Mr. Offor describes these patents as follows:—"1. A secondary battery, of a more perfect description than any hitherto introduced, and which has been worked for more than five months with complete success in the offices of this company. 2. An automatic arrangement for regulating the supply of current to the batteries, in the form of a master cell, which cuts off the current when the accumulators are fully charged, and thus prevents the injury to the plates owing to the generating of free gas, which causes their destruction under other systems. 3. A meter for registering the quantity of current used and constructed so as to enable householders to ascertain at any moment the consumption of electricity in any form of incandescent lamps employed. 4. A regulator for automatically keeping the current of electricity constant. 5. An improvement in the construction of incandescent lamps, by means of which the duration of the carbon filament is prolonged, and the light increased. 6. A lamp-holder and switch combined, and a telescopic sliding electrolier, which can be raised or lowered without extinguishing the lamps. 7. A circuit-shunter, by which if a lamp be broken, a reserve lamp can be immediately lighted in its place automatically. 8. An improvement in dynamo machines, providing for currents of different tensions to be taken off at the same time, and especially adapting the machine as a motor for tramcars, &c." Mr. Offor goes on to say that, "As the business connected with these patents developed, it was found that it could be more conveniently carried on as a separate company in which all the interests involved could be consolidated, and in consequence a company has been formed called 'The Consolidated Electric Company,' with a nominal capital of £100,000, in fully paid-up shares of £1 each, of which both companies hold 20,000 shares as representing their interest in the profits of the company. The working capital is supplied by the Provincial and the South Eastern Companies jointly, on debentures bearing 8 per cent. interest, repayable by 50 per cent. of the nett profits, as shown in the audited balance sheets. The Consolidated Electric Co. will be managed in the same offices and by the same directors and staff as the two companies above named with the addition of James Paxman, Esq. (of Davey, Paxman, and Co.), of Colchester, and J. Kincaid, Esq., C.E., of London, as additional directors. A suitable factory has been taken at 67A, Cow Cross-street, London, which is now being fitted with the necessary machinery and plant. The manufacture of the accumulators and other patented articles, besides motors, switches, cut-outs, safety fuses, ammeters, voltmeters, and all kinds of electrical apparatus, will, I hope, be in full operation during next month. The method of electrical distribution adopted will be kown as the B. T. K. system, those letters forming the initials of the three inventors, Messrs. Beeman, Taylor, and King."

Gas versus Electricity.—A paper on this subject was read a few days since by Professor Barrett before the Royal Society of Dublin. During the reading of the paper and the discussion, which occupied more than one evening, the theatre of the society was lighted by means of thirty-two Swan lamps, supplied and fitted up by Messrs. Edmundson and Co., of Dublin and London, the current being supplied by a Siemens dynamo. We make the following extracts from a report of Professor Barrett's paper:—"In order to arrive at a satisfactory conclusion he said that they must compare gas under the best known conditions of burning with the results of private experience of the electric light. Furthermore, they must take as the price of gas not that which might happen to be paid for it to private gas companies, but the price at which gas could profitably be sold when the gas works were in the hands of municipal authorities, with an able and energetic secretary managing the gas works. Under such conditions they found that, with a good burner, from four to six times as much light could be obtained per cubic foot of gas as from the common burners generally in use. Secondly, by carburetting gas with some hydrocarbon, such as naphthalene, upwards of 60 per cent. was saved in the cost of gas lighting. Thirdly, under efficient corporate management of gas, such as existed in Birmingham, Leeds, Carlisle, and other towns, gas could be sold at a profit at 2s. per 1,000 cubic feet. If all those conditions were fulfilled he affirmed that in the present stage of electric lighting gas was the cheaper illuminant, although exceptional cases existed where water power was to be had, and gas works were absent, and in which electric lighting was more economical. Such a case was that of Mr. Barton's house at Glendalough. The cost of the installation of the electric light was the main item, and that cost was only worth incurring where there was a very large amount of artificial light needed, such as in factories, &c., and then only when a large amount of night work was done. The time limit when children were employed in factories was 277 hours of darkness a year, and at that limit the electric light did not pay. When 1,000 hours were required per year then it began to be profitable; and the larger the amount of time it was needed the more favourably it compared with gas. The comparative results of electric and gas lighting as tried in Crossley's Mills, Halifax, were as follows:—For 277 hours in the year the cost of the arc electric light was 8s. 4d. per hour, while an equal amount of gaslight cost 3s. 7d. per hour when the gas was 2s. 6d. per 1,000 cubic feet; 4s. 6d. per hour when the cost of the gas was 3s. 4d. per 1,000 feet; and 5s. 5d. per hour when the cost was 4s. 2d. per 1,000 feet. When, however, 1,000 hours of artificial light were required then the cost of the electric light became 3s. 5d. per hour, while the cost of the gaslight remained the same. But the arc electric light was too dazzling for rooms, and required constant attention. With regard to the incandescent electric lamps, the filaments used in them lasted for about a thousand hours per lamp. No doubt great improvements would be effected in storage of the electricity and in the machinery requisite for electric lighting." In the course of the discussion which followed, Mr. Wigham spoke of the loss which occurred from the bad burning of gas. He pointed out that the lighthouse gas burner exhibited in the theatre by Messrs. Edmundson burned 244ft. of gas in an hour, and gave a light equivalent to 9·87 candles for each cubic foot of gas consumed. In Irish lighthouses nine of these lights were employed, and only two in English lighthouses. He was not favourable to the adoption of the arc light in lighthouses, as it had not the requisite fog-piercing power.—Mr. M. A. Fahie thought that the great stumbling block in the way of electric lighting at the present time was the enormous charge made for the necessary apparatus.—Mr. Moss mentioned the results of his experience in the employment of the electric lights in the theatre in which they were sitting. The total cost of lighting it with electric lamps was 3s. 2d. for three hours each evening, and that represented the cost of machinery, fuel, wages, &c. Coal gas, which gave considerably less light, would cost 3s. 9d. for the same time, but extra expenses for repairs, &c., connected with the electric light would probably bring the cost of the latter up to about the same. He believed that electric lamps would be particularly well adapted for a library.

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ELEMENTARY ELECTRICITY.

VIII.

The action of Voss's machine for a short time after it is first started is precisely the same as that of the replenisher. In it two paper armatures with small pieces of tinfoil beneath them are attached to the back plate of the machine, and serve as inductors. The carriers consist of six circles of tinfoil attached to the revolving plate. The contacts are made upon metallic buttons attached to the carriers by little brushes of gold tinsel. Two of these brushes are attached to a cross arm, or diagonal conductor, and serve to put the opposite carriers into connection with one another. The others are connected with the paper armatures by means of a metal arm. A very small difference of potential between the paper armatures, which they generally acquire by unknown or accidental causes, is sufficient to start the action of the machine, and to charge up the armatures to a high potential.

When the armatures are strongly electrified a new action begins to take place. Not only does the electricity pass from the metallic brushes to the metal carriers, but it begins to stream from the rows of points, which are attached to the diagonal conductor on each side of the brushes, upon the glass plate, so that the portion of the plate which is opposite the negative inductor becomes positively electrified, while that which is opposite the positive inductor becomes negatively electrified. The revolving glass plate thus begins to act as a carrier itself, and presently its positively electrified surface comes in front of the negatively electrified armature. The carrier comes in contact with the brush when it is between it and the armature, and thus gives up its charge to the armature; but the glass cannot dispose of its charge in this way, but retains it until it comes opposite the points of the prime conductor, when negative electricity streams off the points upon the plate, neutralising the positive charge of the plate, and even electrifying it negatively under the inductive action of the armature. This causes the prime conductor to become positively charged. The opposite prime conductor becomes negatively charged at the same time and in the same way. The circuit of the electricity is completed in the sparks which pass between the conductors. The portions of the glass plate which we are considering having passed in front of the prime conductors now come opposite the diagonal conductor, when the same action takes place as before, unless the revolving plate has been charged by the prime conductors to the full extent which the armatures can induce, in which case the diagonal conductor becomes inoperative. If the discharging knobs of the prime conductors are placed in contact so that there is no resistance to the passage of electricity from one to the other, the prime conductors take the place of the diagonal conductor in charging the glass plate and carriers by radiation, but if the conductors are separated, and happen to be charged nearly to the same potential as the armatures, then very little discharge will take place from the points of the prime conductors, and the diagonal conductor alone will maintain the action. If the machine be worked in the dark, it will be observed that if the prime conductors are in contact, or separate but uncharged, the brushes and glows will appear on the points of the prime conductors, and not on the diagonal conductor. If the prime conductors are separated by a considerable distance, the brushes and glows on their points will diminish as they become charged, and will appear on the points of the diagonal conductor, where they will steadily increase in intensity; and if the prime conductors be separated to the full striking distance of the machine, the discharge from their points will disappear just before the spark passes, but it will reappear on the prime conductors and disappear from the diagonal conductor immediately after the spark.

It is generally found in fine weather that the potential of the air increases as we ascend from the earth's surface, the rate of increase being generally equal to the electromotive force of several Daniell cells for each foot through which we ascend. Sometimes the difference of potential per foot exceeds the electromotive force of 100 Daniell cells. The potential of the air at a given height above the earth is one of the quantities continually recorded at fixed observatories.

If the air be at a positive potential, and a conductor be surrounded by the air, but placed in connection with the earth, the conductor will be at potential zero, and will be negatively electrified. In order to bring the conductor to the potential of the air, it must be placed on an insulating support, and then deprived of its electrification.

If it were possible to remove the whole of the outer surface of the conductor, the induced electrification might be carried off with it and the conductor left unelectrified, and, therefore, at the potential of the air around it. On connecting the conductor with an electrometer the latter would not, however, attain the potential of the air unless the capacity of the conductor were very great compared with that of the electrometer.

If the conductor be insulated and connected with the electrometer, and if a very sharp point be attached to the conductor, electricity will pass off the point so long as there is any considerable charge induced upon the conductor, that is, so long as the potential of the conductor differs considerably from that of the surrounding air; but, unless it is extremely sharp, the point will become inefficient before the potential of the conductor approaches very closely to that of the air.

If a burning match or gas flame be in communication with the conductor, the flame will form a part of the conductor itself, and will be negatively electrified so long as the potential of the conductor is less than that of the air immediately surrounding the flame. But the negatively electrified flame is continually being dissipated into the air, carrying its negative electrification with it, and being replaced by another flame, as it were, which in turn becomes electrified at the expense of the conductor, and this process goes on until the conductor, and the quadrants of the electrometer connected with it, are raised to the same potential as the air which *immediately surrounds the flame*. In connection with his portable electrometer, Sir William Thomson employs a burning slow match to raise the potential of the plate of the instrument to that of the air in the neighbourhood.

Sir William Thomson's water dropping collector, as employed for the determination of the potential of the air at fixed observatories, consists of a metal tank of water supported on an insulating stand and connected with one electrode of a quadrant electrometer, the other electrode of which is put to earth. A long tube, suspended by insulating strings, conveys the water from the tank to the point at which the potential of the air is to be measured. At this point the water is allowed to escape from a jet and break up into drops. If the potential of the tank is lower than that of the air at the point where the drops fall, each drop, being in connection with the conductor, will be negatively electrified, and in falling will carry off its negative electrification with it. This action will continue until the potential of the tank is equal to that of *the air immediately surrounding the drops at the point where they break away*, and when this is the case the drops will fall away unelectrified, and the potential of the tank will undergo no further change. The electrometer, therefore, will register the potential of the air at the point where the drops fall away from the jet; or, if a continuous stream of water fall for some distance, the potential registered will be that of the air where the stream breaks up into drops. If the tank be originally at a higher potential than the air at the point where the drops fall, the drops will be positively electrified until the potential of the tank has been sufficiently reduced.

In fixed observatories the water dropping collector is usually employed in conjunction with the quadrant electrometer, and the light reflected from the mirror of the electrometer is allowed to fall on sensitised paper, which is wrapped round the surface of a cylinder or barrel. The cylinder is caused to rotate by clockwork, and thus the position of the needle, and, therefore, the potential of the air, at all hours of the day is recorded.

In a previous paper we discussed the energy of a Leyden jar or battery. It is now desirable that we should endeavour to learn where this energy resides. We are justified in thus devoting special attention to the Leyden jar, inasmuch as it is the type of all electrified systems. Take, for example, a sphere suspended in the centre of an otherwise empty room,

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and positively charged. There will be on the interior of the walls of the room a quantity of negative electrification numerically equal to the charge on the sphere, and thus the system will be equivalent to a Leyden jar in which the sphere serves as the inner coating, the walls of the room as the outer coating, and the air as the dielectric. No electrified system under consideration is complete unless we can in this way show it to be equivalent to a Leyden jar.

If a Leyden jar is so constructed that its inner and outer armatures (or coatings) can be removed by means of insulating handles, and if the jar be charged and then stripped of its armatures, the latter will be found to be almost unelectrified, but upon replacing them in their proper positions the jar can be discharged. If, instead of replacing the same armatures, a new pair of armatures were fitted to the jar, the discharge could be obtained with equal facility. This experiment indicates that the energy of the charged Leyden jar does not reside upon its armatures, but upon or within the glass itself.

When a Leyden jar is charged to a very high potential, a spark will sometimes pass through the substance of the glass, destroying the jar, and frequently pulverising the glass in the neighbourhood of the perforation. Before the glass can yield to the electric forces, it is clear that it must be strained beyond its elastic limits, and up to its ultimate strength. Hence we may conclude that before the jar is charged sufficiently for a spark to pass the glass must be in a state of strain. To produce this strain work must have been done, and the glass, like a bent spring, in relieving itself from this state of strain, is able to do an amount of work equivalent to that which has been done upon it (if its elasticity be perfect). We are thus led to regard the strained condition of the glass as the form which the energy of the charged Leyden jar assumes, and as all the electrified systems with which we are concerned in the study of electrostatics differ from a charged Leyden jar only in the nature of the dielectric and the forms and relative positions of the electrified surfaces, we naturally infer that the energy of all electrified systems is due to a state of strain of the dielectric, or insulator, which separates the oppositely electrified surfaces. According to this view the conductors in an electrostatic system simply serve to bring the electric charges to their surfaces. The dielectric is the arena of all electrostatic phenomena.

Faraday supposed that the particles of a dielectric in an electric field are thrown into a state of polarisation, each particle being electrified positively on one side and negatively on the other, and that in this way the electric force is communicated from point to point in the field. Maxwell showed that electric phenomena can be accounted for by supposing that there is a tension in the dielectric in the direction in which the electric force acts, accompanied by an equal pressure in every direction at right angles to the force, and that such a system of stresses is compatible with the equilibrium of the dielectric. The energy of the dielectric due to the state of strain into which it is thrown is the energy of the electrified system. The mechanism by which Maxwell supposed this state of strain to be brought about is consistent with Faraday's theory of polarisation.

When a Leyden jar is charged we must regard the glass as thrown into a state of strain, being exposed to a tension in the direction of its thickness, and an equal and opposite pressure at right angles to this direction. When the jar is discharged this state of strain is suddenly relieved, and the pent-up energy appears in the discharge.

When a glass fibre is twisted and then released it is found that it does not immediately return to its original state, but having nearly regained its original condition in the first rebound it afterwards returns only very slowly, so that a very long time elapses before the glass is in exactly the same condition as it was before the strain. Other (imperfectly elastic) substances exhibit similar phenomena in a more or less marked degree. The same behaviour appears in the discharge of the Leyden jar. The glass does not at once return to its original condition, and restore, in the first discharge, the whole of the energy employed in charging the jar. But if, after the first discharge, the jar be left for a time, it will be found possible to obtain a second discharge (much smaller than the first) from it, and after another interval a third discharge and so on, the discharges becoming successively feebler. The charge left in the jar after the first discharge is known as the "residual charge" of the Leyden jar.

All dielectrics do not allow of the transmission of electric force with equal facility. Thus, if two balls be charged so that they repel one another with a force of one dyne when separated by one centimetre in air, and if the balls be then placed in paraffin oil, the force between them will be considerably less than one dyne when they are at the same distance apart, and to obtain a repulsion of one dyne at a distance of one centimetre in paraffin oil the charges must be considerably increased. Hence, if we were to determine the unit of electricity by finding the amount which would repel an equal amount at a distance of one centimetre with a force of one dyne, and were to repeat our experiments in different media, each different dielectric would furnish a different unit, that obtained in air (or vacuum) being the least.

Since the forces between charges of electricity depend on the medium through which they act, it follows that the quantity of electricity required to raise a conductor to unit potential will depend on the nature of the dielectric which separates it from other conductors in the neighbourhood.

Def. The ratio of the capacity of a condenser having any given substance for its dielectric to that of an otherwise precisely equal condenser having air for its dielectric is called the specific inductive capacity of the substance.

The letters S.I.C. are sometimes employed as an abbreviation for specific inductive capacity.

The measurement of the specific inductive capacity of a dielectric is a very difficult operation, on account of the complications introduced by the phenomenon of "residual charge." The difficulty is greatest in substances which, like glass, are of very complex chemical constitution. To reduce as far as possible the errors arising from this cause attempts have been made to measure the capacities of the condensers when they are charged, and discharged successively many thousands of times in a second.

The title of Specific Inductive Capacity was invented by Faraday, who constructed two precisely equal condensers, each consisting of a sphere insulated within a larger hollow sphere, the latter having an aperture for the passage of the electrode of the inner sphere. Faraday first proved the equality of the capacities of the instruments when the space between the spheres was occupied by air, by charging one condenser, measuring its potential by Coulomb's torsion balance, then connecting it with the second condenser, and again measuring its potential, when it was found that the potential was reduced to one half of its former value. Hence the charge was reduced to one half, and the capacities of the condensers were therefore equal.

Faraday then half filled the space between the spheres in one condenser with shellac, charged the air condenser, and divided the charge between the two, after measuring the potential of the charged condenser. On again measuring its potential it was found to be reduced to about two-fifths of its former value. Hence the capacity of the shellac condenser was one and a half times that of the air condenser. From this Faraday inferred that if the whole space between the spheres had been filled with shellac the capacity would have been doubled, and he, therefore, concluded that the S. I. C. of shellac was about 2.

Faraday ("Exp. Res.," 1,252-1,317) attempted to measure the specific inductive capacities of several substances by means of the apparatus just mentioned. He came to the conclusion that all liquids and solids have a specific inductive capacity greater than that of air, but he could detect no difference between different gases or gases at different pressures.

The measurement of the specific inductive capacities of transparent dielectrics is of great interest in connection with Clerk Maxwell's electro-magnetic theory of light, for, according to this theory, the specific inductive capacity should be equal to the square of the refractive index of the medium "for light of infinite wave length" (ultra-red rays), in the

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case of all substances whose magnetic permeability is sensibly equal to that of air. An account of some of the modern methods of measuring specific inductive capacity will form the subject of the next paper.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XVII.

The insulation resistance of cables is usually determined by the method explained in Nos. IX. and X. We refer to the daily tests at the works, and to such as are taken under conditions when there is no disturbance, or as little as possible; for even in a factory testing room it is impossible to make such provision as will ensure a total absence of opposing interference of one kind or other. The causes which are likely to bring this about are various. The action of coiling a cable into or out of a tank in which, or in the immediate neighbourhood of which the cable under test is placed, or the transfer of the latter itself to another tank, which is sometimes necessary, and which need not prevent the performance of the operation, will cause electrical disturbance in the charged section. Vibration from the machinery will affect the cable, and thence produce irregularity in the galvanometer deflections. Atmospheric disturbance is not so common, though sometimes troublesome. The earth plates are occasionally the cause of trouble; local currents are set up which disturb the test circuit and confuse the observations; but it is chiefly at shore stations, during or after submergence, when cables are subject to the influence of earth currents, which on some lines are very powerful, so much so that it is impossible to get correct results by any method. Under these conditions the spot travels up and down the scale, wandering and swinging both ways even when the cable is not charged. Various devices have been adopted to counteract this disturbance, one or two of which we shall discuss by and by. It is not merely a matter of interesting inquiry, but one that is well worth looking into. The test now to be considered is known as that by loss of charge, the principle being that which underlies the charging qualities of cables regarded as condensers. There are various methods of making it, and the galvanometer or electrometer may be employed for the purpose. We are now concerned with the former of these instruments, and have two forms of test to explain in this number. A few preliminary remarks are necessary to give a clear impression of the meaning of the operation, and to show how the desired object is attained by the method in question. We have explained in a former paper what insulation resistance is, and what are its relations to the general properties and office of a submarine cable, and it is from a consideration of the various conditions and their bearing on one another that we are enabled to deduce a rule for estimating an unknown quality in any particular section from others that are known. It is in such examinations that the value of algebra as an aid is made apparent; fortunately, a comparatively slight acquaintance with it is sufficient, as we shall see when presenting the various formulæ governing the working out of all the tests.

As the learner knows, a cable, say in water, connected (with one end free in air) to a battery, one pole to the conductor and the other to earth, will receive a certain charge regulated by what is called the capacity of the cable, and by the potential of the battery. If the battery be now disconnected, the cable leaks, parts with its charge, which is said to discharge slowly through the insulating cover (its dielectric) to the water outside, in other words to earth. This is the familiar way of expressing the conditions. Of course the charge also escapes at the end, which is insulated from earth, but for our purpose we may neglect the consideration of this feature, and regard the leakage or loss of charge as from the outside of the whole surface of the conductor through the insulating sheath. Under these circumstances, the charge escapes at a certain definite rate. If five per cent. of the whole charge, that of full potential, escape in the first minute, then five per cent. of the *remaining* charge will be lost in the second minute and so on, following the rule of compound interest; this is the first point to be noted. In the next place, it must be remembered that what is called the capacity depends on the nature of the dielectric; all substances have their specific insulating quality, or, in other words, as we may put it, their conductive disability. The quality termed insulating resistance, when viewed in relation to the character of a cable, is a desirable property; it is the insulating resistance of a bad conductor. The specific resistance of dielectrics, such as gutta percha, india rubber, &c., is, then, a point of great importance in this connection, and though it is impossible to form an exact table of relative specific resistances for such substances, yet a sufficiently correct estimate has been made, and they have been tabulated on the ground of numerous experiments, from which we are enabled to calculate the different qualities of cables, as their capacity, resistance, &c. Air is taken as the standard, regarded as unity, and gutta percha, the usual dielectric for cables, is stated as 4·3. To explain this more clearly, as we observed just now, the capacity of a condenser, or a cable, regarded as such, depends on the quality technically known as the "specific inductive capacity" of its dielectric, the reverse of which is the (specific) inductive resistance. The higher the inductive capacity of a dielectric in a condenser the greater the charge which it will take. Having air as 1, and gutta percha as 4·3, an air condenser will take a charge of 1 as compared with 4·3 for the same condenser if gutta percha were substituted for it; therefore, in calculating or in comparing two such condensers, whatever value we might give to the capacity of that having air between its opposing plates must be multiplied by 4·3 to give the value of the capacity of the gutta percha condenser. This quadruple feature may be called a negative quality, for inductive *resistance*, and not capacity, is what is required in a dielectric.

A third point to be remembered in connection with the means for framing a rule to express the measurement of this insulation resistance is one that has been already mentioned. The potential of a charge in a condenser or a cable is represented by the deflection which it produces when passing through a galvanometer.

Summing up, we find that the insulation resistance can be determined by noting the difference of potential between any two periods of discharging the condenser (or cable), the time being carefully noted. Thus, if it be charged to a certain potential, and at once discharged, then again charged to the same potential, and be allowed to leak for, say, one minute, and again discharged, we can note the fall of potential by the comparison of the two deflections; then, supposing the capacity to be previously known, we have the conditions for calculating the insulation resistance. From these a formula has been constructed which will be more fully explained further on, but which is based on the facts which we have noted. The rate of leakage, and, therefore, of the fall of potential, as shown by the discharges, follows the rule of compound interest which determines the value of the ratio or comparison of the two deflections to be a logarithmic sum, and not a simple (or natural) numerical value. Without going into the working it may be as well to write the formula here, since it is possible the learner may not be quite sure about it, as he may meet it under two different forms in different text books. It is usually given thus—

$$R = \frac{26{\cdot}06 \times t}{F \times \log \frac{P}{p}},$$

signifying that the insulation resistance of a cable tested in this way is equal to, or measured by, 26·06, multiplied by the time in minutes between the first and second (or first and third, &c.) deflections, and divided by the capacity of the cable in microfarads multiplied by the logarithm of the ratio of these deflections, the result being in megohms. The value 26·06 is merely the product of the 60 seconds in a minute, and the coefficient expressing the difference between two different systems of logarithms. If the formula be written with the time in

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seconds, and the *Napierian*, or natural system, it will be $R = \frac{t}{F \times \log_{\epsilon} \frac{P}{p}}$, which in the common, or *Briggean* system, is $\frac{\cdot 4343 \times t}{F \log \frac{P}{p}}$, and $\cdot 4343$ multiplied by $60 = 26 \cdot 06$ as nearly as possible.

There are several tests on this principle, that is, the fall of potential being observed in different ways, or rather, for different periods. Some electricians prefer to note the time in which a cable falls to half potential, and this again is determined in various ways. We are commencing with the comparison of potentials at intervals of from one to five or ten minutes, using the galvanometer for the purpose. We may observe here that the electrometer enables us to watch the actual fall of potential; it is as if we could see into the interior of the cable and notice what is going on. With the galvanometer we can only observe the potential from time to time, and estimate the rate of fall by comparison of the deflections. The test may be made either by charging or discharging the cable; that is to say, instead of noting the fall of potential by the discharge of what remains after the minute's leakage, we can let the cable leak for the fixed time and then recharge, the deflection resulting from which operation will represent the amount of charge necessary to replace what has escaped. In this case the full potential is shown by the deflection got

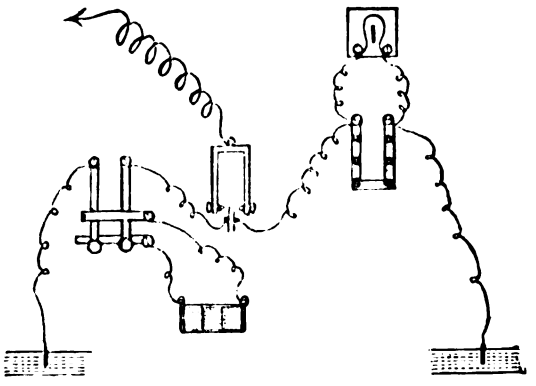

FIG. 39.—Insulation Resistance (Discharge Test).

by charging through the galvanometer in place of discharging as in the other form. The connections for the discharge test are shown in Fig. 39, and are very simple. The Lambert key connects by one front terminal with the battery key and the other with the galvanometer, the end terminal joining up with the cable which is supposed to be insulated at the further end (where the arrow points).

A few words on the comparison of the two operations, the charge and discharge tests, may serve to remove any difficulty that may be felt on the subject. The conditions appear to indicate that something very different in each case is being done. When the "discharge" test is taken in the manner we have suggested, the reduced potential in each succeeding deflection is compared with or related to the full potential or sudden discharge, technically speaking, so that each reading represents a different potential, namely, that of the charge at the particular instant. In the "charge" test, after taking the reading for full potential, the succeeding deflections are the result of a proportion of the charge sufficient to make up for that which has been lost by leakage through the dielectric. In the first example the full charge passes through the galvanometer at first, and afterwards a less amount at each succeeding discharge. In the second example, the full charge also passes through at first, but afterwards more at each repetition, and only enough to fill up the loss. The two cases are reconciled, so to speak, by a slight variation in the working out. The charge test is worked out (by an obvious calculation) so as to give us the discharge that would have resulted if it had been taken in the other way. It is assumed, indeed it is regarded as a fact, that charge and discharge are always equal; that is to say, a perfect cable shows the potential to be the same whether we measure by one or the other. A charge from a given number of cells produces the same deflection in passing through the galvanometer whether entering or leaving the cable.

(TO BE CONTINUED).

BALL'S UNIPOLAR DYNAMO.

At the invitation of Mr. C. W. Raymond, who has charge in England of the interests of the company owning this machine, we recently inspected the unipolar machine at work. Before describing the machine, we may, perhaps, refer to Mr. Sabine's report, a copy of which has been sent to us, and which is as follows:—

3, Great Winchester-street, London,
20th March, 1883.

Chas. Ward Raymond, Esq.

Sir: According to your instructions, I have tested the continuous current dynamo-electric machine of Mr. Ball, at present at 41, Kirby-street, Hatton-garden. This machine consists of a long rectangular frame of soft iron, coiled so as to form the field magnets, and which longitudinally supports the axes carrying two bobbins of the Pacinotti type. The main peculiarity of the machine is that each bobbin is rotated in the presence of only one magnetic pole, the opposite side of the bobbin facing a neutral point of the field. Hence the name "unipolar," by which the inventor designates his dynamo. The effect of this so-called unipolar arrangement, in so far as the field is concerned, appears to be that the rectangular soft-iron frame is converted into two long electro-magnets with two poles, only one being presented to each of the rotating bobbins, instead of four shorter, and proportionally weaker, electro-magnets having four poles, as in the ordinary way, by which two opposite poles would be presented to each of the bobbins.

When I tested the system, the dynamo was run with six arc-lamps, also said to be of Mr. Ball's invention, the dynamo being worked on the "series" system, that is to say, field magnets, armatures, and lamps all joined up in series. The speed of the machine was not so regular as could have been desired, and the Morin dynamometer, by which the power given to the dynamo was measured, would have worked steadier had it been driven quicker or with a heavier load.

The following are the mean results which I found:—

Current in circuit = C = 15·0 amperes;

Potential difference between terminals = E = 195 volts;

Resistance of dynamo = r = 4·5 ohms;

Speed of dynamo, 1,650 to 1,715 revolutions per minute;

Speed of dynamometer = s = 332 revolutions per minute;

Indicated pull on dynamometer, less pull when circuit open } = k = 52 kilo.

From these values,

1. Given to dynamo for electrical work,
$$\frac{1 \cdot 5\ k\ s}{60 \times 76} = 5 \cdot 68 \text{ h.-p.}$$
2. Accounted for in outer circuit,
$$\frac{E\ C}{746} = 3 \cdot 92 \text{ h.-p.}$$
3. Accounted for in inner circuit,
$$\frac{c^2\ r}{746} = 1 \cdot 35 \text{ h.-p.}$$

The proportion accounted for electrically, therefore,
$$\frac{5 \cdot 27}{5 \cdot 68} = 0 \cdot 92,$$
of which $\frac{3 \cdot 92}{5 \cdot 68} = 0 \cdot 69$ was accounted for in the lamps. This would leave only 8 per cent. for the so-called Foucault currents.

Photometric measurements were made with one of the

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lamps, placed apart from the others in a dark recess, the light of the five remaining lamps not being measured.

The following mean results were obtained during the observations:—

Current in lamp = 13·9 amperes.
Potential difference = 40·1 volts.

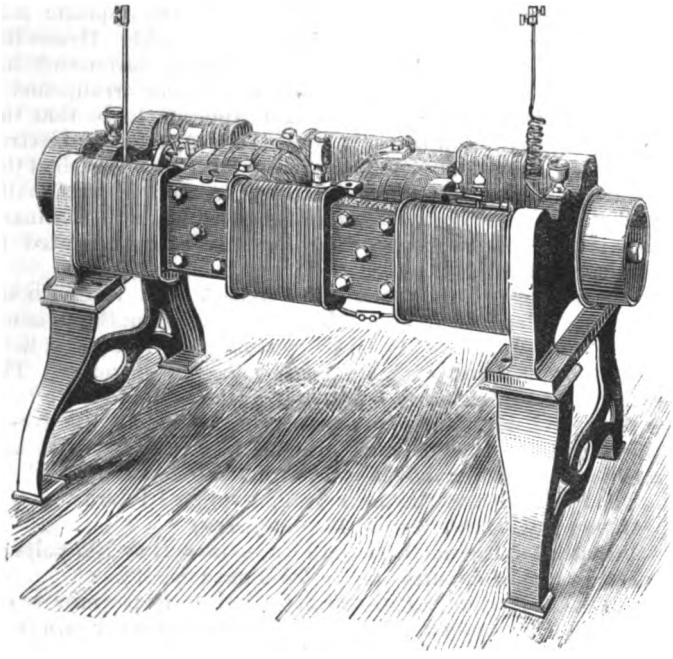
Accounted for in lamp $\frac{13{\cdot}9 \times 40{\cdot}1}{746} = 0{\cdot}75$ h.-p.

The illuminating effects were as follow:—

Position of arc with regard to photometer.	Illuminating power.	
	Observer.	Per 1 h.-p. accounted for in the lamp.
	Standard Candles.	Standard Candles.
22° below	602	802
11° below	626	835
Horizonal	887	1,183
11° above	1,213	1,617
22° above	1,831	2,441
31° above	1,859	2,479
35° above	1,690	2,253

(Signed) Yours faithfully, Robert Sabine.

The figures given in this report are very similar to those obtained by us, except that we made no photometric measure-



Pall's Unipolar Dynamo.

ments. The number of revolutions per minute varied slightly around 1,700, the horse-power as indicated by the dynamometer was about 5·25 with the six arc lights in circuit. The lights were steady, and the machine seemed to heat very little. The time during which our observations extended, however, was too short to prove anything with regard to heating, but on general grounds we should expect such a machine to run cool. The accompanying illustration will show better than mere explanation can the type of machine designated as "Unipolar." It has two armatures, each 8in. in diameter, revolving in opposite directions. Each armature contains 60 sections of wire, wound as in the Pacinotti or Gramme rings, the commutator also having 60 sections. The wire is No. 14 (Am. gauge), of copper, weighing about 19lb. on each armature, or about 38lb. on the two. The field magnets are wound with No. 8 (Am. gauge), copper wire, the weight being about 130lb., the total weight of wire thus being about 168lb. In the more recent machines we are informed much less wire is used, there being in the above machine an excess of something like 35 per cent. The driving power is conveyed by two belts, each ·5in. wide, running over 8in. pulleys. The size of the magnet bar is 7in. by 1·125in. The following details are obtained by advices from New York of an improved five-light machine on this principle:—The total weight of copper on field magnets and armature is about 88lb., the total weight of the machine being altogether about 350lb., or about 70lb. per lamp. The number of revolutions in this machine for the five lamps is 1,190 per minute. In this machine also there are two armatures with but one pole piece to each armature and but one commutator on one shaft. These revolve in the same direction, one belt only being used. In this machine while the armature still has sixty sections the commutator has a hundred and twenty. The internal resistance is 2·6 ohms.

Another machine of this type that has been built is a 15-light machine, with two armatures, each 12in. dia., containing about 3,000ft. (80lb.) of No. 14 wire. It has six magnet bars, each 2in. by 2in., three at top and three at bottom, containing about 4,444ft. (200·5lb.) of No. 8 wire. The total weight of this machine is about 997lb., or 66lb. per lamp; made up thus:—

As above	280·5lb.
Iron	661
Commutators (Cu)	30
Bearings (composite)	26
	997·5lb.

The internal resistance of the machine is given as 7 ohms. With a periphery speed = 3,600ft. per minute = 1,146 revolutions, current is supplied for 15 arc lights.

The six-light dynamo reported upon by Mr. Sabine, and seen by us, is said to have been running in New York or London during the greater part of twelve months—and has had no repairs. It was taken to pieces, cleaned, and painted prior to shipment, otherwise no work has been expended upon it.

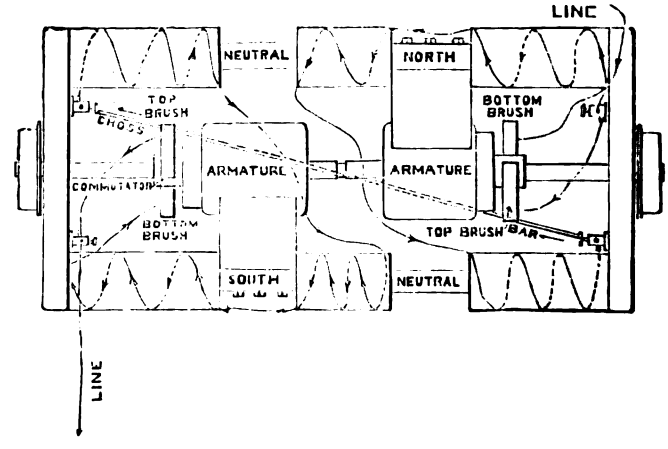


Diagram showing Method of Winding, and the Connections.

The accompanying diagram shows the method of winding, and the connections.

It is difficult to express an opinion as to the merits of this machine, as at first sight it seems to be the opposite of wise to drive an armature through a complete revolution and cut lines of force only once, when, as in the Gramme machine, opposite sides of the armature may be used, of course with two poles. Experiments are said to have been made to compare the effects obtained with those obtained in a bipolar machine, and the result was in favour of the unipolar. We shall be interested in the details of such experiments.

INTERNATIONAL ELECTRIC EXHIBITION, VIENNA.—We have been officially informed that the Austro-Hungarian railways will grant a reduction of from 70 to 80 per cent. in the freight on all objects sent to the Electric Exhibition at Vienna. This reduction will relate equally to the transport of goods to and from Vienna.

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REIS'S TELEPHONE.*

The following is a copy of an autograph description of Reis's telephone, which has been presented to the library of the Society of Telegraph Engineers and of Electricians by Mr. William Ladd, member:—

[Copy.]

Institut Garnier, Friedrichsdorf.

Dear Sir: I am very sorry not to have been in Francfort when you were there at Mr. Albert's, by whom I have been informed that you have purchased one of my newly-invented instruments (telephons), though I will do all in my power to give you the most ample explanations on the subject. I am sure that personal communication would have been preferable, specially as I was told that you will show the apparatus at your next scientifical meeting, and thus introduce the apparatus in your country.

Tunes and sounds of any kind are only brought to our conception by the condensations and rarefactions of air or any other medium in which we may find ourselves. By every condensation the tympanum of our ear is pressed inwards, by every rarefaction it is pressed outward, and thus the tympanum performs oscillations like a pendulum. The smaller or greater number of the oscillations made in a second gives us, by help of the small bones in our ear and the auditory nerve, the idea of a higher or lower tune.

It was no hard labour, either to imagine that any other membrane beside that of our ear could be brought to make similar oscillations, if spanned in a proper manner and if taken in good proportions, or to make use of these oscillations for the interruption of a galvanic current. However, these were the principles which guided me in my invention; they were sufficient to induce me to try the reproduction of tunes at any distance. It would be long to relate all the fruitless attempts I made until I found out the proportions of the instrument and the necessary tension of the membrane. The apparatus you have bought is now what may be found most simple, and works without failing when arranged carefully in the following manner:—

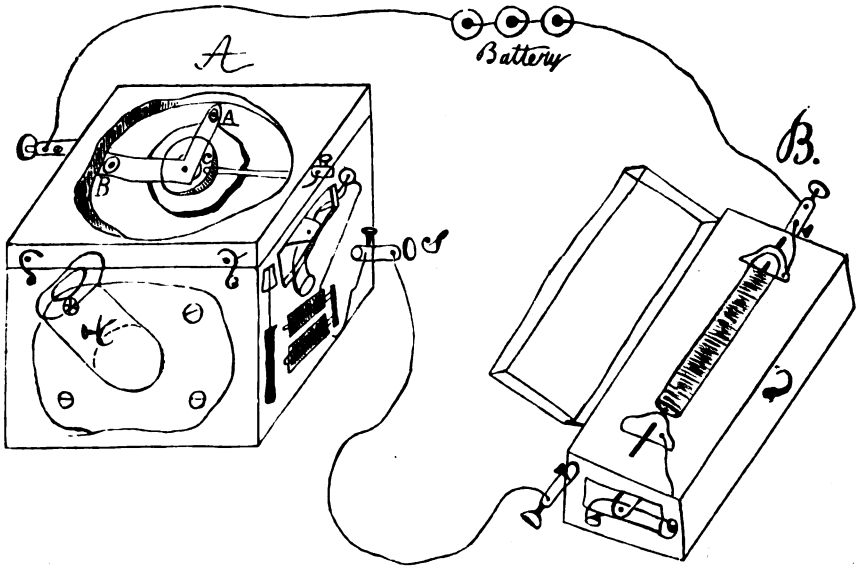
The apparatus consists of two separated parts, one for the singing station A, and the other for the hearing station B.

The apparatus A is a square box of wood, the cover of which shows the membrane *b* on the outside, under glass. In the middle of the latter is fixed a small platina plate, to which a flattened copper wire is soldered, on purpose to conduct the galvanic current. Within the circle you will further remark two screws; one of them is terminated by a little pit in which you put a little drop of quicksilver, the other is pointed. The angle, which you will find lying on the membrane, is to be placed according to the letters, with the little hole *a* on the point *a*, the little platina foot *b* into the quicksilver screw, the other platina foot will then come on the platina plate in the middle of the membrane.

The galvanic current coming from the battery (which I compose generally of three or four good elements) is introduced at the conducting screw near *b*, wherefrom it proceeds to the quicksilver, the movable angle, the platina plate, and the complementary telegraph to the conducting screw *s*. From here it goes through the conductor to the other station B, and from there returns to the battery.

The apparatus B, a sonorous box, on the cover of which is fixed the wire spiral with the steel axis, which will be magnetic when the current goes through the spiral. A second little box is fixed on the first one, and laid down on the steel axis to increase the intensity of the reproduced sounds. On the small side of the lower box you will find the corresponding part of the complementary telegraph.

If a person sing at the station A, in the tube *x*, the vibrations of air will pass into the box and move the membrane above, thereby the platina foot *c* of the movable angle will be lifted up, and thus will open the stream at every condensation of air in the box. The stream will be re-established at every rarefaction. In this manner the steel axis at station B will be magnetic once for every full vibration, and, as magnetism never enters nor leaves a metal without disturbing the equilibrium of the atoms, the steel axis at station B must repeat the vibrations at station A, and then reproduce the sounds which caused them. Any sound will be reproduced if strong enough to set the membrane in motion.



Reis's Telephonic Apparatus.—Facsimile of Drawing sent by Reis to Mr. Ladd.

The little telegraph which you find on the side of the apparatus is very useful and agreeable for to give signals between both of the correspondents. At every opening of the stream, and next following shutting, the station A will hear a little clap, produced by the attraction of the steel spring. Another little clap will be heard at station B in the wire spiral. By multiplying the claps and producing them in different measures, you will be able, as well as I am, to get understood by your correspondent.

I am to end, Sir, and I hope that what I said will be sufficient to have a first try; afterwards you will get on quite alone.

I am, Sir,

Your most obedient servant,

Friedrichsdorf, 13/7/63. Ph. Reis.

To Mr. William Ladd.

* From the *Journal of the Society of Telegraph Engineers and of Electricians* for March.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

X. CLARK (BOSTON).—*So far as we know there is no work published dealing specially with the subject you mention. You will find information on the subject in the tariff book of the Eastern and other Cable Companies, and also in articles by Sir J. Anderson, together with correspondence arising therefrom, published in the early numbers of* "THE ELECTRICIAN."

J. L——R (GAINSBOROUGH).—*Write to the secretary, City and Guilds of London Institute, Gresham College, E.C., who will give you every information. The Central College you refer to is, we believe, in connection with the Institute, but we doubt if it is yet ready for actual work; perhaps you were thinking of the College at Finsbury. Information concerning both can be obtained from the same source.*

E. G. DORNBUSCH.—*You will find something referring to the paragraph about a "Remarkable Electrical Discovery" in our Notes this week.*

A. R. E. A.—*We must call your attention to Ohm's law,* $C = \frac{E}{R}$. *Now* E *being fairly constant,* C *will depend upon the external and internal resistances you may have. Then, again, do you want the current for one second or for a long period? We should have imagined that any elementary book, such as Ferguson, would give you the information you require.*

J. P. (GLOUCESTER).—*The particulars you ask for are to be found spread about in various periodicals, but, so far as we know, are not to be found in a collective form. The transmitters are, we believe, patented.*

A LOVER OF LIGHT.—*We cannot insert your letter unless you send your name and address, though these need not necessarily be published. We are afraid that, though very well as an exhibition, the mode of lighting which you describe is hardly practicable. Americans are certainly celebrated for "big things," but we doubt if they will ever light a town, even a village, properly, by means of one powerful arc light. You forget the shadows thrown by houses. Light, to be of use, must be distributed.*

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REIS'S TELEPHONE.

The *Journal* of the Society of Telegraph Engineers, which for some time past has been the subject of much complaint on account of both the quality and quantity of its contents, is this month redeemed from insignificance by the appearance in its pages of a copy of a letter addressed to Mr. Wm. Ladd, and bearing date 13th July, 1863, from Ph. Reis, explanatory of his telephone, accompanied by a fac-simile drawing from the same hand. We could have wished the epistle fac-similed as well as the diagram, for then the lettering would have agreed in both, which is not the case as they now stand. But, allowing for this defect, we may thank Mr. Ladd and the society of which he is a member for contributing this interesting and important piece of evidence on a matter which has lately given rise to so much doubt and disputation.

We have reproduced both the letter and the diagram in another column just as we find them in the *Journal*, and it should be understood that the remarks we are about to offer upon them are subject to possible correction, either from the receiver of the letter, who, having purchased a specimen of Reis's apparatus, understands it, no doubt, better than any one who has only the drawing and explanation to guide him; or from it happening that the fac simile is not quite accurate in every detail. Reis evidently knew how to draw, and, although he has made a blunder here and there excusable in a rough sketch, the figure as a whole is clear and accurately pencilled. On this account we are inclined to suspect the fac simile rather than the original draughtsman of one serious defect to which we shall draw attention presently. We must, however, take the drawing as it stands for the purpose now in hand.

As regards the letter its obscurity is unavoidable. Mr. Ladd would have added much to the favour he has conferred in publishing Reis's letter if he had supplemented it with an explanation in good English—that is to say, told us what *he*, by the light of the instrument itself, understood its inventor to mean in certain passages, which, owing to Reis being a foreigner, are open to diverse interpretations. At a first reading all seems tolerably clear, but directly we try to follow the description by means of the drawing matters get confused, and on one or two vital points we are left in utter uncertainty. On the other hand, the diagram disabuses us of the startling impression created by first perusal of the letter:—"The angle, which you will find lying on the membrane, is to be placed according to the letters, with the little hole *A* on the point *A*, the little platina foot *B* into the quicksilver screw; the other platina foot will then come on the platina plate in the middle of the membrane." Here a point dipping into a mercury cup on a membrane at once suggests the solution of the whole problem; but, in reality, it is nothing of the sort. If the quicksilver had been in the middle of the membrane its object might have been open to another construction, but being where it is the purpose it actually serves is only to make good contact where the current enters at *B*.

This being so we may fix our attention on the centre of the box A. We confess our inability to follow the text of the description:—"The cover shows the membrane *B* on the outside, under glass." This is sufficiently confusing; what follows is still more so:—"In the middle of the latter is fixed a small platina plate to which a flattened copper wire is soldered, on purpose to conduct the galvanic current." According to this the uppermost platina plate is affixed to the glass cover; this, indeed, may be so, but in the diagram the flattened copper wire—which we take to be represented by the narrow strip running from near *C* in a right hand direction—is *not* soldered to anything. It is drawn as passing under the plate, and its blunt end terminates in space. A further complication arises through the presence of

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a small circle indicated in the centre beneath the elbow angle of *A, B*. But for the word "small" being applied to the upper plate this lower circle might be mistaken for the plate on the membrane. We can only infer that it is some detail redundant for the essential object though present in the apparatus.

We may take it, therefore, that "the platina plate in the middle of the membrane," and upon which rests the central "foot," is represented by the circle whose ragged outline passes *under* the "angle" as well as under the strip of copper. It may, however, represent merely the outline of the membrane. In fact, if we follow the text and the picture, trying to reconcile the two, we may conceive either that the membrane is below the "angle" or above it, that the smaller platina plate is affixed to it or is held rigid and independent. Further, it may be that the current is normally permanent, or is normally broken. In short, after giving the arrangement every attention possible, we find that its essential feature is not in these details at all, is much simpler, and at the same time much less efficient than we had imagined. We, of course, refer to the transmitter; the receiver has striking merits of its own, which, however, not being now in question, need not be discussed.

Now, what is the essential feature of this telephonic transmitter? We have no hesitation in answering, as, indeed, we have answered many times before, that it is a make and break contact, capable of transmitting musical tones, but unreliable for reproducing articulate speech. If any doubt remain as to this, let the reader turn to the last paragraph but two of Reis's letter:—"If a person sing . . . . the vibrations of air will pass into the box, and move the membrane above, thereby the platina foot *C* of the movable angle will be lifted up, and thus will open the stream at every condensation of air in the box." In the next sentence we are told, "the stream will be re-established at every rarefaction;" and in an early part of the letter he speaks more explicitly of using the oscillations of a membrane "for the interruption of a galvanic current." His diagram corroborates the language he employs. Doubtful as are the relative positions of the parts, there is no doubt whatever as to their action. A platinum point is made to oscillate so that once in every "full vibration" of a membrane a galvanic current is established. This is what the letter and the diagram tell us—this and nothing more.

Reis himself makes no claim in his letter to being able to transmit speech. He calls the transmitting station "the singing station," and in describing the mode of procedure he uses the words, "If a person sing." Elsewhere he has spoken with seeming disappointment, or rather with puzzled surprise, that the receiver failed to reproduce the vowels satisfactorily. This, according to the extract printed in our columns on the 10th inst., at page 394, was in the year 1860-61. The letter we are discussing bears date 1863. It would be difficult to discover in what respect the instrument we have been describing was superior to that of two years earlier date. The later one we may assume was the perfected instrument; it could not speak except by fortuitous accident. This was admitted though the reason was not known. But *we* know the reason, and knowing it we know also how to make Reis's contrivance do more than he was able to make it do; but not much more. To use his own words, it can only be trusted for the "reproduction of *tunes* at any distance."

It is agreeable to turn from the purely negative part of our task, in order to express our admiration of Reis's conception of the problem he had to solve. On this point the second paragraph of his letter is most interesting. Whether he was completely master of the conditions upon which sounds are communicated to the auditory nerve cannot be determined with certainty on the evidence of a brief letter of this kind; but as regards the conditions for reproducing them electrically we see plainly enough that he was within very measurable distance of complete mastery. Those who have followed him, and have succeeded where he failed, have ungrudgingly acknowledged his great merits; at the same time, they may, perhaps, be pardoned for pointing out that, so far as appears from the evidence yet adduced on his behalf, Reis did not succeed in transmitting articulate speech by electrical currents, and that he never could have succeeded with the transmitter he was using down to the date of his letter to Mr. Ladd. He might have succeeded with his *receiver*, but that is quite another matter.

CORRESPONDENCE.

ELECTRICAL ACCUMULATORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In a commercial country one is accustomed to excuse and to pass without comment a large amount of "tall talk" in connection with wares that are offered for sale. But some of the remarks of Sir Daniel Cooper, at the annual general meeting of the Electrical Power Storage Company (Limited), of which a report appeared at p. 454 of your last issue, appear to me somewhat to overstep the prescribed latitude. In regard to the Brush Accumulator patent, Sir Daniel is reported to have said that "They had consulted some of the best authorities, and they thought there was very little in it. If an attempt were made to work it here, the Electrical Power Storage Company would immediately step in and take steps to stop it." Now, in more senses than one, there is a *great deal* in the Brush Accumulator patent; and I, for one, should be glad to know the names of the "best authorities" who hold the contrary opinion. Then surely Sir Daniel should be aware that any steps his company might take, *directly*, to stop the working of the Brush patent in this country would be perfectly futile, if not disastrous. Such working could no doubt be legally restrained, but not in virtue of any patents held by the Electrical Power Storage Company (Limited). The next statement of Sir Daniel must, no doubt, have had a very telling effect upon the shareholders of his company; but its audacity is simply amusing to those who know practically what has been done and what remains to be done in connection with secondary batteries, or to those who have made a study of the literature of the Patent Office in connection with these appliances. "As far as they knew," said Sir Daniel, "there was really no accumulator whatever, except their own, that was of any commercial value, and, as far as they could ascertain, other accumulators which were talked about were worthless commercially." The means of ascertaining possessed by the Electrical Power Storage Company would certainly appear to be of a most limited character. Of their own battery—to which, as well as to the strenuous and meritorious endeavours made to perfect it, I am anxious to render ample justice—it may be said that it is a very decided improvement upon that of Faure; and it may further be said, in relation to the patents by which it is guarded, that fatal mistakes in electro-chemistry, such as would invalidate every claim, have, in this case, generally been avoided. But to regard this battery, in its present form or as constructed in accordance with the patents just referred to, as the best of those which are, even at the present moment, available, is a mistake which is likely to be confined to those in whom "the wish is father to the thought." Sir Daniel may be excused for not having sufficiently entered into comparative experimental trials; but he surely must be aware, from what has been stated in the most influential journals which have considered the question of secondary batteries, that his own

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opinion as to the exclusive merits of his company's accumulator are by no means universally entertained. Thus *The Times*, in its article of the 14th instant, after cautiously stating that "the Faure-Sellon-Volckmar accumulator is said to be free from the old objections," gives a very plain intimation that the best results are to be looked for in another direction. "Other inventions," says *The Times*, "have produced the lead in a finely-divided powder (*as a mass of interlaced crystals* would be a more correct description), and by compressing this powder into a compact mass they have obtained sheets of very porous lead. The rapidity with which accumulators made of this material can be 'formed' is remarkable, and those who have made experiments on these plates find them superior to any others." It seems then, that after all the excitement which was raised about the Faure battery we are likely to return "eventually to a form which resembles a Planté secondary battery to a much greater extent." In the leading technical journal the same opinion has been much more forcibly expressed.* The truth is, though the fact may be unknown to Sir Daniel Cooper and to the shareholders in his company, that in several directions important advances have been latterly made—by means of continuous experimental work, accompanied with the *minimum* amount of talk—in the construction of secondary batteries. The criticisms of Mr. Edison, and the objections which have hitherto been fairly applicable to all the forms of secondary battery, will, I venture to affirm, soon be out of date. An experimental acquaintance with secondary batteries extending over more than twenty years may, perhaps, enable me without presumption to hazard an opinion on this point.—Yours, &c.,

DESMOND G. FITZGERALD.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to be told *on very good authority* that Mr. Edison, and others of his way of thinking, are mistaken, and also that what was written by me so long ago as December, 1881 (and on a Christmas Day, too!), does not apply to such secondary batteries as may be obtained at the present time; for I must confess that I have not yet seen enough to warrant my indulging even in the hope that what we generally hear in favour of them is true.

1. What is the average life of the very best accumulators of the day?

2. What is the actual first cost of them per electrical indicated power?

3. What is the cost of keeping them in the most efficient state?

Perhaps some of your readers who have neither invented, made, nor sold, any of these accumulators, but who—after buying and trying to work a few of them—have learnt something of their little ways, will give us the benefit of their experience, and so help to answer the questions asked above.

In many cases accumulators will be found very convenient—no sane man doubts this—but will they ever be cheap?

A few right-minded, but not altogether disinterested, people would have us believe that electric lighting with accumulators is Heaven, that without them it is—well—another place; that nothing can save us but faith and lead plates. When we ask for proofs we are told to think of the comforts accumulators bring with them, and to believe!

Now, such preaching as this may be all very well in its way, but too much of it is apt to interfere seriously with the spread of electric lighting, and I fancy that the time has come when the public might be trusted with the truth. Tell us what we must pay!

Poor "Chabot's Ghost" has caught my name, but not my meaning. The man who does not believe in accumulators is to be pitied almost as much as the one who believes that they are perfect, that they are cheap, and that it is impossible to do without them.—Yours, &c., $\frac{W}{g} \cdot \epsilon^{\gamma}$.

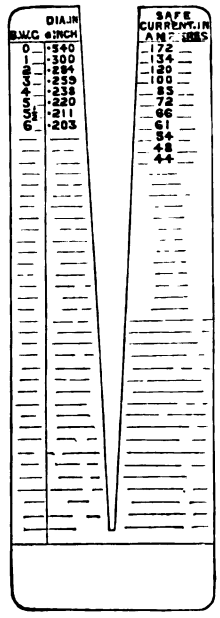
Ty-yr-dyn-gwyllt, the Feast of St. Ananias, 1883.

* *Vide* the *Engineer*, January 5, 1883, p. 14.

A GAUGE FOR ELECTRIC LIGHT ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I send herewith a sketch of a new gauge I have devised for the use of electric light engineers, &c., and which could be constructed by a steel rule maker in quantities at a very nominal rate.



Volk's Gauge for Electric Light Purposes.

On the obverse are columns showing size B.W.G., from 0 to 24, increasing by ½, diameter in inches, and safe current in amperes on the reverse, resistance per 100 yards 96 per cent. conductivity and weight per 100 yards.

The sketch is full size. The thickness should not be less than ⅛".—Yours, &c., M. VOLK.

Ditchling Rise Telegraph Manufactory,
Brighton, March 19, 1883.

THE ELECTRICAL POWER STORAGE COMPANY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In the report in your last issue of a few observations which fell from me on the subject of "Electrical Accumulators" at the recent meeting of the Electrical Power Storage Company an error occurs which, though abstractedly of small importance, I should be glad to have corrected, lest those who have known what my views have been on the subject referred to may think that circumstances have occurred which have caused me to alter or to modify them, the fact being that any difficulties which have intervened to delay their immediate or rapid fulfilment have only served, by the experience gained, to enhance my most sanguine expectations of the ultimate results that may be attained. The words I refer to were, "That I did not think it was *difficult* to realise in the near future the working of machinery, of railways, and of steamers by the aid of that power" (electricity). By the substitution of the word *possible* for *difficult* the tenour of my remark is completely altered.—Yours, &c.,

JOHN S. SELLON.

The Hall, Sydenham, S.E., March 27th, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: We notice in the report in your issue of the 24th inst. of the annual general meeting of the Electrical Power Storage Company that the chairman mentions the various firms who have been supplied with accumulators. May we beg to call your attention to the fact that we received the first set of the Faure-Sellon-Volkmar accumulators sent to Scotland, and have since had them in daily use in exhibiting the electric light in our office here; and, further, we lent

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them to Professor Ayrton for his lecture on "Electrical Locomotion" at the St. Andrew's Hall, Glasgow, on the 8th February last.

Had none of the other firms using accumulators been alluded to we would not have trespassed on your courtesy to correct the omission of our names.—Yours, &c.,

NORMAN and SON,
Electric Light Engineers,
per Alex. Grant.

Glasgow, March 27th, 1883.

WHAT'S IN A NAME?

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to names, titles, &c., I need hardly ask your opinion of the title chosen and adopted by the "Society of Telegraph Engineers and of Electricians," because you have expressed it in your leader of January 27th.

Why seven words should be required to explain the nature of this society when two words would do equally well has always mystified me.

A quarter of a century ago, when electricity was in obscurity, one might have understood why such a long title was used, but in these days electricity is by no means obscure; it bids fair to be the most prominent and important science of our day, and this society promises to be ere long one of the most influential and powerful societies in the world. It is a pity, then, that its name should spoil it.

We have our Geographical, Geological, Meteorological, and other societies. Might I suggest "Electrical Society" as a name for the society to consider. So far as my knowledge goes "Electrical" covers *everything* in which electricity plays a part.

Some day, perhaps, "Royal" may be prefixed to the title. "Royal Electrical Society" would *look* and *sound* well, but fancy "Royal Society of Telegraph Engineers and of Electricians!!!"—Yours, &c., BREVITY.

SIEMENS'S SHUNT DYNAMO.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: As I am making a small Siemens shunt dynamo, I should be much obliged if you would tell me—(1) How is ebonite made, or would boxwood be a good enough insulator for the commutator? (2) How to wind a Siemens dynamo? What thickness of wire should be laid on the field magnets? Their section is 6 × ¼-inch. (3) I propose winding the armature with four different series of coils (using four commutators), and, therefore, propose to wind the field magnets with four coils. Would there be any loss from induction?

Apologising for the length of this letter—Yours, &c.,

F. S.

THE MAKING OF GUTTA PERCHA.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In reply to Mr. W. H. Harrison, who writes in your last issue for information on the above subject, I may say that in a series of Cantor Lectures, delivered by Mr. Thomas Bolas before the Society of Arts in February, 1880, your correspondent will find a full description of the india rubber and gutta percha industries. These lectures were published in the *Journal of the Society of Arts*, which can be obtained at the society's office, Adam-street, Adelphi, W.C., and were also printed in *The Electrician*, Vol. V.—Yours, &c.,

WILLIAM H. PARKER.

Acton, W., March 28, 1883.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending March 23 were £2,133, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

THE ELPHINSTONE-VINCENT DYNAMO.

An exhibition trial of this machine took place on Wednesday, March 21st, and was of considerable interest. In addition to the trial of machines, Mr. Vincent delivered an address. The dynamo shown was one stated to be able to supply the current for 400 Swan 20 candle-power lamps. The motor was one of Mr. Rigg's patent high-speed engines, fitted, as the initiated of our readers know, with piston valves. The engine worked well, and among other attractions the fly-wheel fitted to the engine was not the least conspicuous. The following figures relating to the engine will be interesting:—Cylinder, 12", with 20" stroke; steam pressure, 80lb.; ¼ cut off with all lights on; ⅛ cut off during rest of the time. The Swan lamps wired for the purposes of the exhibition consisted of about 330 45-volt lamps, requiring under normal conditions 1·32 ampere. These lamps were hung on a kind of gridiron in one of Messrs. Unwin's upper warehouses, then 20 lamps were put into the engine room, 18 in the dynamo room, and about 15 more scattered about the building, making a total of 384 lamps. The lamps were arranged 2 in series, thus giving 192 circuits, and as each circuit required 1·32 ampere the total current required was 192 × 1·32 = 253·44 amperes. In addition to the 45-volt lamps, 25 high resistance 94-volt lamps had been fitted in the offices and shops in single multiple arc, each lamp requiring about ·66 ampere, or 25 × ·66 = 16·5 amperes altogether. When the machine was first started the high resistance lamps and about 40 others were run, and the former lamps being on separate leads it was found (using an Ayrton and Perry ammeter) that the result with 17 amperes current was very good. Upon the arrival of the visitors the remaining lamps were gradually put into the circuit about 100 at a time, and then the machine began to have its work cut out. Although we were unable to get figures relating to speed it was quite certain that the speed was largely increased. The current required for all the lamps would be about 270 amperes, at an E.M.F. of from 90 to 94 volts. Judging from the appearance of the lamps when the whole 409 lamps were in circuit we should infer that this number was somewhat too large for the capacity of the machine, and we think we may safely say that instead of 1·32 the current might be about 1·1. The maximum speed was stated to be not more than 950 revolutions per minute. The maximum speed and number of lamps was not continued the whole evening, in consequence of the excessive vibration, but about 150 lamps were kept in circuit at their full brilliancy. In addition to the trials with incandescent lamps a large hand-regulated arc lamp was shown. This lamp did not work noiselessly, and must have proved a hard knot for the engine and machine. Notwithstanding the ordeal the magnet coils of the machine kept cool. We have so recently illustrated and described this machine that we have thought it preferable to enter somewhat into the details of the trial rather than to repeat our previous description.

BREWTNALL'S SUSPENSION FOR ELECTROLIERS.

The object of this invention, by Mr. A. Brewtnall, of Streatham, is to enable the principle of the ball-and-socket joint to be applied to the suspension of electroliers and to the mounting of other swinging or movable fittings for the electric light by providing through the medium of this joint for the maintenance, unbroken, of the electrical circuit, when the electrolier or other fitting is swung or rotated. This is attained by constructing the ball, and its socket, in segments, of metal, separated from one another by segments, zones, or parts of insulating material, the metallic segments or portions of the socket corresponding to similar segments or portions of the ball, and in contact therewith over a sufficient extent of surface to permit of the free motion of the ball in its socket without breaking the electrical connection between the corresponding segments or parts.

The joint is illustrated in the accompanying engraving, in

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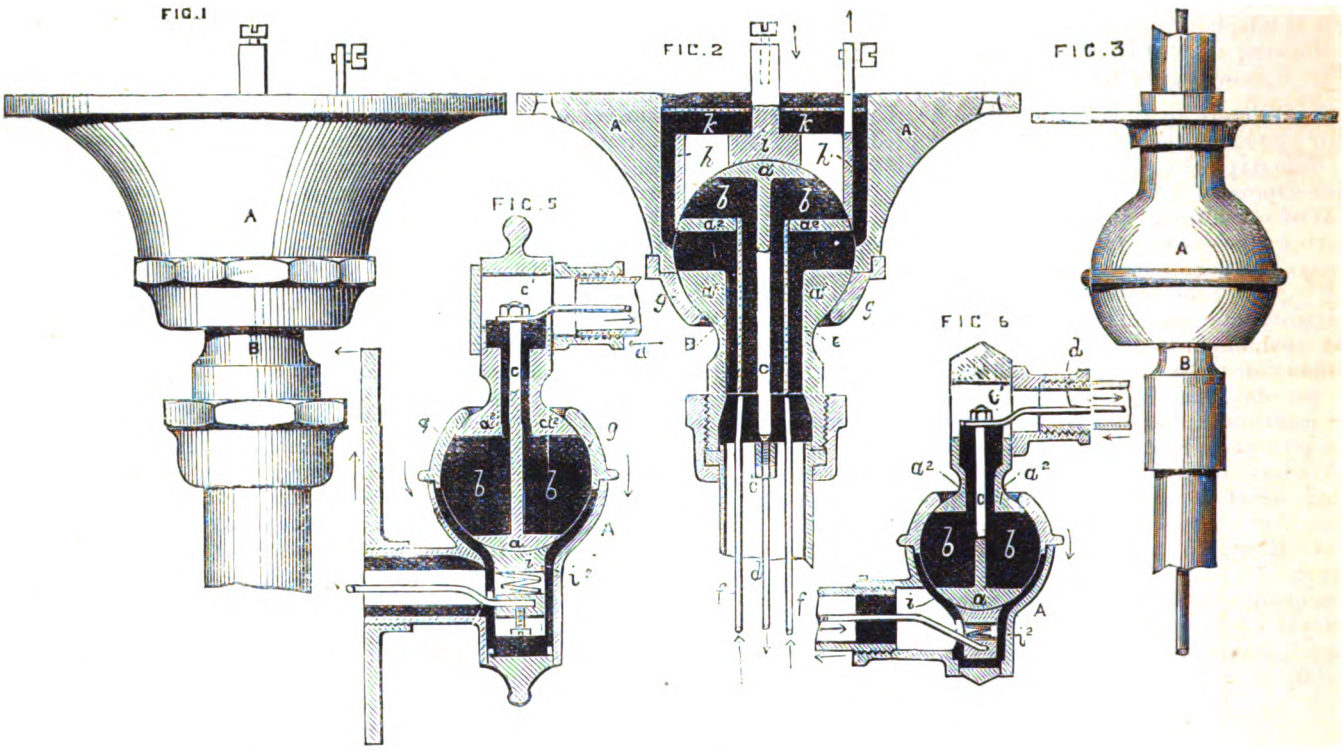
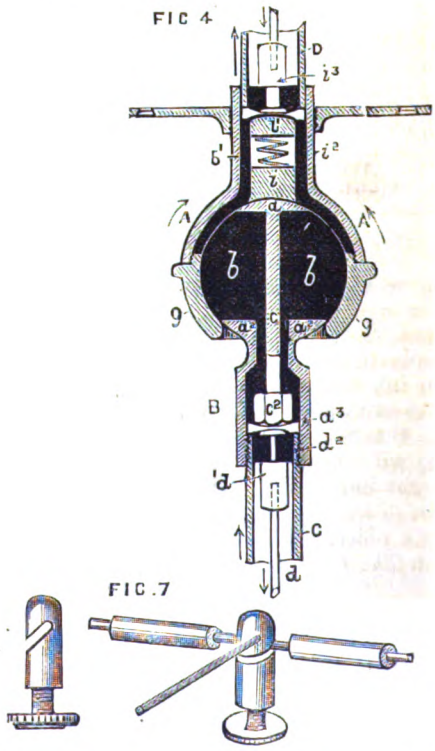
which Fig. 1 is an elevation, and Fig. 2 a central vertical section, of one arrangement of ball-and-socket for the suspension of an electrolier. In this arrangement the ball-and-socket are constructed of a sufficient number of zones or segments to afford a return circuit without using for this purpose the external metal of any part. Figs. 3 and 4 are similar views of a ball-and-socket in which the external metal is used for the return circuit. Figs. 5 and 6 respectively show the application of the ball-and-socket joint to the first and intermediate joints of wall brackets. In these figures



the arrangement is similar to Fig. 4, but the arrangement shown in Fig. 2 might equally well be employed if it is not desired to use the external metal for the return circuit. In all these figures the same letters of reference indicate corresponding parts.

A is the socket and B is the ball. In Fig. 2 the ball is composed of three horizontal metallic segments, a, a^1, a^2, separated from one another by two insulating segments b. The segment a is attached to a central stem c, which leads through the neck of the ball, and is connected by a nut, c, to the wire d leading to the lamp. To the intermediate metallic zone or segment a^1 is soldered a metal tube, e, which also leads through the neck of the ball and terminates in tangs, to which are connected the return wires f from the lamp. The segments b of insulating material are also carried through the neck of the ball and surround the rod c and tube e, and insulate them from one another, and from the third segment a^2. This third or lowest segment takes the wear, and rests in the corresponding gland g of the socket A. This third segment, a^2, serves for the attachment of the main stem of the electrolier in the ordinary way. This socket contains an annular metallic lining, h, which exactly coincides with the zone or segment a^1 of the ball, and is insulated from the outer portion of the socket, as shown. To this lining, h, the return wire is connected at h^1; i is a central stud, having its lower surface concaved to the radius of the ball, so as to make good contact with the uppermost segment, a, of the ball. To this stud the positive wire from the generator is attached, and the stud is insulated by a disc of vulcanite, and is pressed into contact with the segment a of the ball by a disc of soft india rubber, k, beneath the vulcanite, and bearing upon a shoulder of the stud. This india rubber disc, k, also bears at its edges upon the annular lining h, and presses it likewise into contact with the segment a^2. Thus it will be seen that there is perfect freedom for complete rotation, and also for oscillation to any desired extent, of the ball in the socket, without liability of breaking the electrical connection.

In Fig. 4 there are only two metal segments, a and a^2, separated by a segment, b, of insulating material, as shown. The segment a is attached to a central stem, c, as before, but the stem terminates in a nut, c^2, screwed on it, this nut being a sufficient distance within the socket a^3 of the part a^2 to enable the joint to be made as next described; d is the leading wire, fixed at its upper end into a stud, d^1, embedded in a plug, d^2, of insulating material, fitted into a coned seat in the end of the main stem C of the electrolier, from which the stud d^1 projects slightly, so that when stem C is screwed into



its socket, a^3, electrical connection will be made between c and d. The concave stud i, which presses on the segment a of

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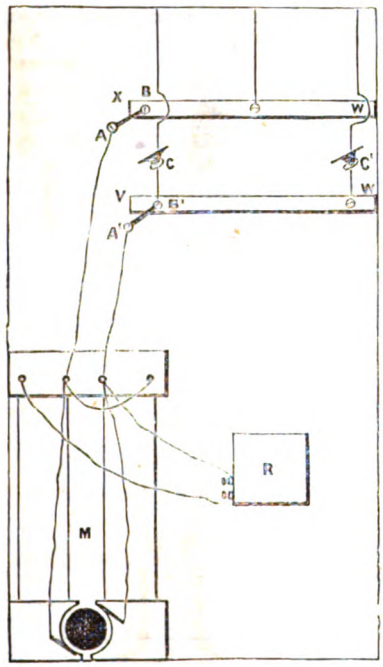
the ball is divided into two parts, i, i^1, connected by a metal spring, i^2, which answers the purpose of the india rubber disc k in Fig. 2. The joint of the leading wire from the positive pole of the generator is made by an insulated stud, i^3, pressed against i^1 in the act of screwing the tube D—which encloses said wire—to the socket A. In this arrangement it will be seen by the arrows that tube C, segment a^2 of the ball, gland g, socket A, and tube D serve as the return conductor. The tube D may be replaced when desired by a terminal.

Figs. 5 and 6 show the application of the same joint to the joints of wall brackets. The essential parts of the joint, being identical with those before described, need no further description, and the slight modification necessary in the bracket itself to adapt it to receive these joints will be apparent from the drawing without special explanation.

Fig. 7 shows one of Brewtnall's patent connectors for joining branch to main wires, slightly modified to suit the requirements of telegraph offices for connecting up the various instruments both on submarine and land lines. The drawings will sufficiently explain its use.—*Engineer*.

THE EDISON SYSTEM IN A SUGAR REFINERY.

An installation has recently been made by the Edison Company of Berlin in the sugar refinery of Messrs. Dannenbaum Brothers, in Warrenton (Braunschweig). The installation consists of eighty lamps, fitted up in the boiling room, crystallising room, mill room, &c. A new method has been adopted in this installation of connecting up the two main conductors with the different branches, which will be readily understood on reference to the following diagram. A B are safety catches, V W two copper bars, C C′ are switches, R regulating box, &c. This method renders testing a very easy matter. All the work, including the laying of 762 metres of underground cable, was completed in less than fourteen days, and gives entire satisfaction to the owners and superintendents of the refinery.



Edison Installation in Sugar Refinery.

Death of Madame Becquerel.—The death is announced of Madame Antoine Cesar Becquerel as having taken place at Chatillon-sur-Loing on the 27th February last, in her eighty-ninth year. She had only survived by five years her celebrated husband, the well-known electrician.

THE FUTURE OF ELECTRICAL ENGINEERING.

As a practical science it is only within the past few years that electricity has taken any permanent hold on the trade and development of the nation.

Its growth in this way has been slow, and the reasons for this are not very far below the surface.

Up to the invention, or, to speak more correctly, the practical application of the electric light, very small attention was given by any of the engineering profession to the subject, and the knowledge of electricity was confined to chemists and scientists, being looked upon by practical engineers as decidedly a laboratory question. The rapid development of the lighting powers of electricity, however, drew the attention of inventors first, and now of engineers, to the matter, and there is no reason to doubt that it is of the highest importance for the science and for the profession alike that they should become intimately connected with one another.

That this will be so, and that the mechanical engineers in the immediate future will hold the direction of electrical work, many facts go to show. It is particularly so with electric lighting. There is no scientific improvement in which the question of economy is so indispensable an item as in this, owing to the peculiarly trying competition to which it is subjected.

This economy, striking at the whole system, affects:—1st. the means of producing electricity; 2nd. the means of conveying it; and 3rd. the utilisation of it. Thus, whether the prime producer of electricity is a steam, gas, or water engine, their economy results from a due exercise of mechanical knowledge in their design, and, as electricity can only be produced in large merchantable quantities by such machinery, the engineers have a great—perhaps, the major—portion of the system under their present control.

The scientific man who has developed the principle of certain means of making or using electricity, must afterwards hand over this principle to more practical and mechanical minds for useful development. The dynamo or generator of electric force well illustrates this point.

The Gramme machine, which was the early inception of the principle, has, under the successive mechanical improvements since applied, become a working success even in the largest sizes, and no doubt, now that its lines of construction are clearly defined, many engineering firms will enter upon its manufacture, and reduce its cost by economies, and the use of special tools.

The transmission of the electric force is at the present time occupying the attention of scores of busy minds, and the scientific world generally is almost weekly anticipating the discovery of some great further step in this direction.

The check from which electric lighting has been for some months past suffering, although due in part to financial overexertion, is yet largely to be accounted for by the commercial failure of the accumulator or storage-battery, for the lack of which the trade is languishing, and in expectation of which, as an economical certainty, extensive electrical projects of supply are deferred.

It is a most fortunate circumstance for the needs of the world at large that the principle of the accumulation or storage of power was demonstrated when it was, as it has given to invention the basis on which to work, and it is not hard to estimate the annihilating difficulties with which the application of electricity would have been confronted without the promise of such assistance.

But it is in the *uses* of electricity that electricians, as distinguished from engineers, at present possess the greatest control; lamps, telegraphs, and telephones are of such delicate mechanism that their design and construction hardly fall within the province of manufacturing engineering, being more properly in that of instrument makers and clockwork.

Yet the question of economical production being of as vital importance here, as in the other portions of the body electric, engineering talent and mechanism must be employed increasingly to cheapen and multiply manufacture.

The blowing in glass of the globes of incandescent lamps is a case in point in which a move has been made.

Up to the present this work has been done by hand, but a

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machine has been recently set to work, which forms these globes from a glass tube, not without the direction of a man, but by taking the work out of his hands and revolving, blowing, and heating under his control. Such a step is in the most necessary direction.

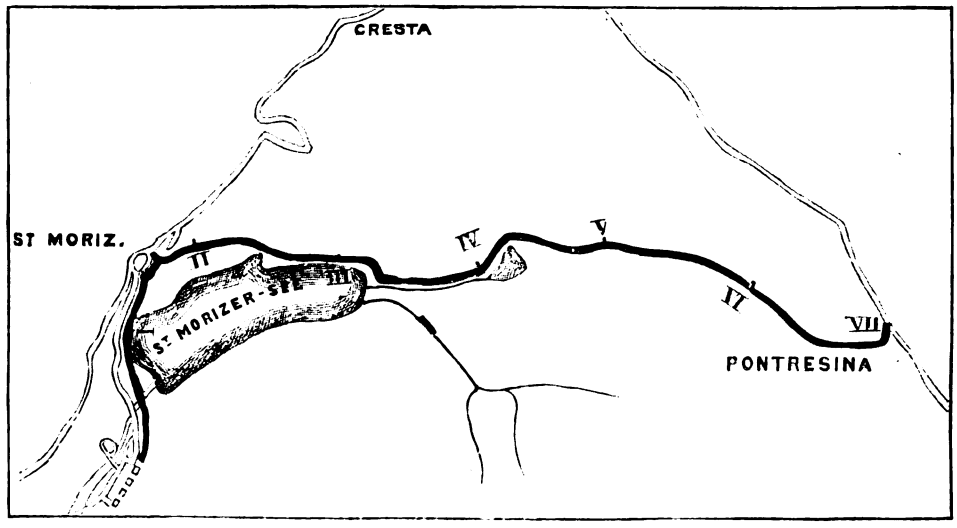
It is, perhaps, as a means of universally divided power, simpler, cleaner, more portable, and cheaper than fuel and steam, that electricity is hoped for by the general community. It is the realisation of this that will make electricity the "thing of the future," and give us the right to call ours the "electric age." That we are a distance from it, immeasurable because unknown, cannot be denied, and if it is to be accomplished it must be by engineering ability of the highest order.

The present is a period which admits of but one line of thought for a member of so varied a profession, but we have now, and shall increasingly possess, able minds among the scientific, military, and manufacturing engineers devoted to these subjects by duty or inclination.

Two great factors are operating to produce attention, namely, the prizes, which are great, and the competition, which each year grows greater.

AN ELECTRIC RAILWAY FOR SWITZERLAND.

A scheme is under consideration to establish, at an early date, an electric railway between St. Moriz and Pontresina,



Map showing the Route of the Proposed Electric Railway.

a distance of 7½ kilometres (4·6 miles), as part of a more extended scheme. Previous to the opening of the St. Gothard tunnel, traffic from Switzerland to Italy went *viâ* Coire and Chiavena, over either the Julian or the Splugen passes. The Swiss railway at present terminates at Coire, and next year the Italian railway system will be complete to Chiavena. The complete scheme is to join Chiavena with Coire by an electric railway by two routes. The distances are, from Coire to St. Moriz 76·5 kilometres, St. Moriz to Chiavena 48·8 kilometres, making a total of about 125 kilometres (77·5 miles). At present a concession is only asked for the St. Moriz portion, and it is stated that it is almost certain this will be granted to Herr Badruth. If this is successful a further concession will be asked for to the Engadine, and then over the pass to Chiavena. The district is well furnished with natural water-power, and it is proposed to utilise this water-power for the motive-power that will be required. We give a sketch map of the district, which no doubt is well known to many of our readers.

ELECTRICAL TRANSMISSION OF POWER IN MINES.

As the question of the transmission of power by means of electricity is engaging a great deal of attention just now, we think the following abstracts of two recent articles will be interesting. They are taken from *Abstracts of Papers in Foreign Transactions and Periodicals*, Vol. LXXI., Part I., published by the Institution of Civil Engineers.

The first is entitled "An Application of Electricity to the Transmission of Power at the Mines of La Péronnière," by Messrs. Charousset and Bague," and is abstracted from the *Bulletin de la Société de l'Industrie Minérale*, Vol XI., 1882, p. 5 :—

The energy in this case is transferred through conductors 1,200 metres (1,309 yards) long, from the mouth of the pit to the head of an incline 110 metres (120 yards) long, where it is employed to drive a windlass and draw the coal tubs up the incline. There are two generating dynamos and two receiving dynamos, connected by the four conductors so as to form two independent systems and circuits, of which it is not generally found necessary to employ more than one at a time. The connection between the Gramme dynamos and the driving machinery at one end, and between the dynamos and the intermediate gear of the windlass at the other end, take place by means of friction-pinions made of compressed paper. The machines ride upon a centre situated below each of their octagonal frames, and are kept up to more or less intimate contact by screws in the case of the generators, and by a system of levers, under the immediate control of the attendant, in the case of the receiving machines, care being taken to provide against excess of pressure by a stop. As these machines when receiving a current always run in the same direction, whatever may be that of the current, the intermediate gearing contains a system of conical sliding-pinions for reversing the motion of the winding-drum.

The four machines employed are all octagonal and similar to one another. The ring is divided into four parts, passing successively before as many magnetic poles, alternatively positive and negative. Each pole is formed by two coils whose cores are at right angles to each other, and have one pair of similar ends brought thus together.

The other ends of these eight cores are fixed in the octagonal frames, which therefore serves to connect opposite poles. Each of the four poles nearly completes the quadrant of a circle; and from the quadruple character of the magnetic field four brushes are necessary to each machine. The coupling is in series—that is, the entire current flows through

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the electro-magnet coils of both the generating and the receiving machine.

The conducting cables are formed of sixteen copper wires of $\frac{11}{10}$ of a millimetre in diameter, the metal employed being perfectly pure. At the beginning of operations these wires, placed in juxtaposition, were first covered with a thickness of paraffined cotton, which again received two envelopes of cloth treated with Chatterton's compound, and was enclosed in india rubber and tarred. But, in spite of these precautions, the insulation did not remain perfect, on account of the damp situations in which parts of the cable had to be placed. A covering of lead was tried in damp places, but this turned out dangerous in practice, and the cables finally adopted were as follow:—

16 wires of copper $\frac{11}{10}$ diameter,
2 coats of paraffined cotton,
1 coat 5 millimetres thick of gutta percha,
2 windings of Chatterton cloth,
1 thick coat of tarred cotton;

and the purchasers themselves finally covered the cables with a paste of the following composition:—

57 pints of Norwegian tar,
38 „ resin,
5 „ suet,

in order to protect them, as well from heated gases as from damp.

The original cable, still maintained in the dry parts of the mine, cost 1·25 franc per metre; that finally employed in the damp situations, 3 francs per metre.

The trouble which arose before the question of the cables was finally settled was instructive. When the cheaper cable was employed for the whole circuit, the insulation in damp situations became defective in about one month. Shocks were received by the miners even through the rock in the neighbourhood of the conductors, and these shocks finally caused the rupture of the cables themselves. The nature of these ruptures was peculiar. The ends of the wires exposed were untwisted, and the surface had lost its polish, being honeycombed with little cavities filled with a brown, or sometimes black, dust. The paraffined cotton, which was very white when the cable was new, presented a green colour, and this discolouration extended to the exterior of the cable, and even to the walls of the pit. At four or five centimetres from the ends the wires were found to be intact. The oxide and carbonate of copper indicated a chemical action going on between the copper wires and the water in contact with the external envelope, under the influence of the electric current. It was on account of these ruptures that the lead covering was applied, but the safety of the cable was not found to be increased by this means. On one occasion the men below observed some large sparks in the pit, which greatly frightened them. The driver, warned by the galvanometer that something unusual was taking place, stopped the engine, and an investigation showed that the lead had been melted in several places, and thrown against the walls of the pit. Where the lead had been thus removed the Chatterton cloth was calcined, and the wires presented globules of metal which had been fused. All this occurred in a quarter of an hour, the receiving dynamo running free at the time. Since the application of gutta percha to the cables no such mishap has occurred. The following case of leakage occurred one day. The hauling cables, which are of iron wire, are attached to cast-iron projections on the drum, and by this means were in metallic connection with the bed-plate of the whole underground part of the installation. These cables were observed suddenly to be electrified, and at the same time a current passed through the telephone wire and set the bell ringing. Otherwise nothing abnormal took place in the running of the machinery. The phenomenon lasted two hours, during which it was impossible to touch the hauling cables without producing small disturbances, the effect increasing with the distance from the drum. On the bed-plate itself no shock was forthcoming.

The sudden disappearance of the phenomenon shows that it was due to some passing cause—perhaps to the presence of metallic dust on the india-rubber washers separating the bed-plate from the circuit traversed by the electric current; or, it may be, to the contact of one of the cables at a faulty point with the earth, for it was at that time that the cables began to show faulty insulation.

On a subsequent occasion a fault in the bottom insulation of one of the machines certainly caused a derived current, and the hauling cable, then no longer attached to the metallic framework of the drum, was electrified more strongly than on the previous occasion.

It is very necessary to keep the nuts which secure the brushes firmly in the sleeve or holder quite tight. The neglect of this once caused the loosening of the brush, with the generation of large sparks.

The needle of the galvanometer indicated a much stronger current than usual, and the steam engine was pulled up as if by a brake. The paper friction-gear became at the same time heated.

The following table gives the usual performance of these machines. It is based upon an average of experiments. The galvanometer used is simply a needle, placed over the conducting cables. It will be observed that its indications are proportional to the squares of the difference of velocities.

—	Work Indicated in Engine-Cylinder per Minute.	Useful work in Coal raised per Minute.	Indications of Galvanometer.	Speed of Generating Dynamo. Revs. per Minute = V.	Speed of Receiving Dynamo. Revs. per Minute = v.	Difference of Speeds V − v.	Practical Efficiency.	Electrical Efficiency = $\frac{v}{V}$.
	Ft.-lbs.	Ft.-lbs.	°				Per Cent.	Per Cent.
1. Steam engine quite unloaded	135,402	...	...	...	...	...	...	...
2. Steam engine in gear	198,763	...	...	...	...	...	...	...
3. Steam engine driving generating machine with circuit open	224,802	...	...	...	...	...	...	...
4. Receiving machine running unloaded	230,009	...	4·5	1,280	...	...	...	...
5. Windlass running, with no coal tub	264,728	...	9·0	1,280	975	305	...	...
6. Windlass running, with 1 coal tub	455,679	55,549	16·0	1,280	880	400	12·2	67·7
7. Windlass running, with 2 coal tubs	526,776	96,778	19·5	1,280	830	450	18·6	64·8
8. Windlass running, with 3 coal tubs	594,553	137,572	20·0	1,280	810	470	23·1	63·2
9. Windlass running, with 4 coal tubs	663,989	173,592	25·5	1,280	780	500	26·1	61·0

The second abstract is taken from an article by M. Graillot' in the same *Bulletin*. It is entitled "Experiments on the Transmission of Power by Electricity at the Mines of Blanzy," and reads as follows:—

These experiments were instituted in order to arrive at a knowledge of the efficiency to be expected in transmitting the energy of a steam engine above ground to machinery in the mine. The motor employed was a condensing Watt engine, without expansion, whose efficiency was assumed to be, during the experiment, constantly at 0·60. An intermediate shaft, with pulleys and belts, conveyed the motion of the engine to the generating dynamo.

The distance, 634 metres (= 691 yards), was represented by two coils of cable, each 604 metres long, and composed of nine copper wires $\frac{11}{10}$ millimetre in diameter, enveloped successively in cloth, in india rubber, and in lead. The remaining 30 metres (33 yards) were made up by a brass wire 5 millimetres in diameter. The receiving dynamo actuated the winding machinery by frictional contact with the intermediate gearing. The course of investigation adopted was to make a series of observations, by cylinder-diagrams, of the power necessary to drive the intermediate gearing alone at different velocities. This, reduced in the proportion of 10 : 6, was in each case deducted from the power (reduced in an equal ratio) required in the various experiments with loads. The balance was taken to be the power transmitted to the

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generating dynamo, and this is finally compared with the useful work done by the windlass in weight raised.

The results obtained are open to the criticism, passed upon them indeed by Mr. Rossigneux, that they rest upon the assumption of the constancy of the efficiency co-efficient of the steam engine under differing loads; but the results obtained are valuable, as showing the variation in the useful work when the other conditions remain fairly uniform, and as qualifying the dogma that as the work given out diminishes the efficiency increases. The length of the conductors within the limits (634 metres and 30 metres) of these experiments seemed to have no sensible influence upon the efficiency. When the work to do was small the efficiency was small, and rose as the work approached in value that for which the machinery was designed. Thus, with the long conductors, when the work utilised was 0·73 h.-p., the efficiency was 17·25 per cent.; at 1·15 h.-p. it varied between 26 and 34 per cent.; at 2 and 2½ h.-p., between 40 and 51 per cent.; and at 3½ and 4 h.-p., between 37½ and 51 per cent. With the short conductors, at 1½ h.-p. of useful work, the efficiency was 28 per cent.; and at 2 and 3 h.-p. it varied from 40 to 51½ per cent.

LITERATURE.

Electric Illumination. Engineering Series. Edited by James Dredge.

The time has come when the public, as well as engineers and inventors require a systematic account of the apparatus employed in electric lighting, to enable them to select the most suitable, as well as to see what has been done and what is required to be done. As yet this information is only to be gathered from a multitude of scattered papers and a few small works of a partial and incomplete character. This work, which has space enough to promise something to its readers, and comes from a source which may be expected to supply abundant material, will therefore be received with some interest. Being the work of several writers it must be expected to be unequal in character, nor can a perfect consistency of treatment be looked for.

The chapter on electrical units with which the work opens is singularly disappointing, to use a mild expression. There already exists sufficient misapprehension as to the various units, owing to the complication introduced by the C.-G.-S. system, which has been so much employed after the original definitions of the units had become familiar under the simpler metre-gramme-second system employed by the original committee. The needless changes of names made by the Paris committee will add to the difficulties of future students by making the books already published mislead them, and in this chapter we have a guidance through the difficulties of much of that order which is calculated to place the proverbial traveller "in the ditch."

Speaking of the *erg* as having the practical fault of being too small, after saying "this difficulty was met by devising a second unit, the meg-erg, equal to one million ergs," we have the astounding information, "a minor unit, the erg-ten, equal to 10 ergs, was also introduced. This Mr. W. H. Preece suggested should be called a watt!" The genial face of Mr. W. H. Preece must have been worth seeing when he read this; however, he likes a joke, and, in the requisite selection of language fitted to express his feelings, he may have pitched upon George the Third's favourite exclamation—What! what! Certainly, whatever an erg-ten may be, it is not a watt. It is usually supposed that the barbarous term means erg $\times 10^{10}$, or ten thousand million ergs, which is rather inversely a minor unit. The watt is 10^7 ergs.

The chapter is made up of extracts from various reports, with definitions such as "*Electromotive Force*, or that mysterious power which tends to produce a transfer of electricity from one point to another of a conductor," and "*Capacity*, or the quantity of electricity necessary to raise the potential of a conductor from zero to unity." But there is nothing to convey to the mind any theoretical or practical conception, either of the individual units or their systematic relations, so that the utility or purpose of this chapter is somewhat doubtful.

A description follows of instruments for measuring and recording electric currents, such as the galvanometers of Deprez and of Ayrton and Perry, and the meters of Edison. Of the latter it is said that they "are a remarkable example of originality of invention;" but although the Weber-meter, to which the remark especially relates, is twice figured and described, nothing is said of the identical device patented two years earlier by Mr. Sprague, and which is also omitted from the classification of inventions under the head of "Current Meters," although the patent containing it appears under several other headings. Nor is there any description of the meter of Mr. Boys (beyond its mention in the list of patents) or of any other mechanical or integrating meter except that of Mr. Lane-Fox.

The chapter on the "Mechanical Production of Electric Currents" gives very clear and good explanations of the principles which govern the relations of electric current and magnetism. The early part of the chapter is especially instructive, though it may be doubted whether the writer does not dwell too strongly upon the idea "that the energy of a current is to be conceived as existing in the space *outside* the wire quite as much as in the wire itself." It is beyond question that the habit of considering the conductor alone as concerned in the development and transmission of current has led electricians to overlook important facts which play an essential part in dynamo electric machines; it is, therefore, proper to bring these facts prominently before the reader, and to show their importance. But it is going as far wrong in the opposite direction to assert, as the first fundamental principle, "That the existence of the energy of electric currents, and also the energy of magnetic attractions, must be sought for, not so much *in the wire* that carries the current, or *in the bar* of steel or iron that we call a magnet, as in the space that surrounds the wire or bar." After all, the substance, the "bar," is the material basis of the magnetic field; it is rather too metaphysical to talk of the solid magnet as merely a "convenient conductor for the lines of force," seeing that these lines of force only exist where there is this material basis to rest upon. Still more fallacious is it to reason about electric currents and their magnetic actions "quite irrespective of the copper wire, which acts as a conductor," seeing that without that wire the forces and actions have no existence. But the classification of the different systems of machines and the theories of the ring, drum, pole, and disc armatures, and the illustrations of the reactions of magnets and currents will atone for some little wandering in the dreamlands of science.

The chapter on the theory of dynamo electric generators is largely based upon the experimental researches of M. Breguet, and deals entirely with the reactions in the Siemens and Gramme armatures in connection with a theoretical examination of the influences operating upon a wire rotating in a magnetic field. But the core of the Gramme ring is treated only as a "magnetic shield," as preventing the inverse action of the lines of force upon the inner layers of wire, and to a small degree as deflecting and reversing the direction of these lines upon the edges and inner side of the ring, so as to convert the inverse into a direct action. No account appears to be taken of the effect of the opposite pole induced in the ring, or of the action of the ring itself upon the wires. This appears to be a very incomplete treatment of the subject, for it is very certain that the direct action of the wires cutting the lines of force of the field magnets is but a portion, and probably a small portion, of the action in the Gramme machine. This subject is, however, dealt with again in the special description of the Gramme machine itself, where it is stated that the core acts as if it were two semicircular magnets acting as though "the iron portion of the ring were fixed, and the coils of surrounding wire were caused to run round it." But this is treated as subordinate to a more important effect. The following sentence describes, or is intended to describe, this more important effect:—"As the lines of force constituting the magnetic field of the two magnets form a series of elliptic arcs joining their two poles (as we have already seen), it

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follows that not only does a large proportion of those lines of force with the ring, thereby causing it to become strongly magnetic, but the convolutions of the induction coils, attached as they are radially to the ring, are moved during its rotation within the magnetic field in directions perpendicular to a large percentage of those lines of force, and therefore in a way specially advantageous to the induction of magneto-electric currents." This is difficult to comprehend, and the probable explanation of its mystery is that some words have been dropped which are necessary to complete the sense. So far as it is comprehensible it would appear to relate to the reaction of the core upon the wire as a magnet traversing a coil. This is in fact the meaning apparently conveyed by a diagram which follows; but this can scarcely be the true meaning, as it would be a direct repetition of the action just treated as of less importance.

Perhaps the most interesting part of this chapter is the explanation offered of the necessity for displacing the commutator brushes of machines to an extent varying with the rate of rotation. This is usually attributed to the action of the iron, which requires time to take up and part with its magnetism. On this the author says: "The presence of the iron ring exercises two influences quite distinct from one another. Firstly, since it requires time to magnetise or demagnetise it, it will necessitate that the contact brushes be displaced a little in advance of their theoretical position, or with an increased lead. This displacement, always in the sense of rotation, will, therefore, diminish the total displacement when the machine is used as a motor, but will increase it when used as a generator. In either case, however, its influence is quite small. Secondly, the presence of the iron ring increases the intensity of the magnetic field, concentrating a greater number of lines of force in it, and, therefore, tending to reduce the deformation in its symmetry. This is a most important influence, and it will be seen that in the case where the machine is used as a generator the presence of iron in the armature tends to bring back the most favourable position of the contact brushes towards the position of symmetry, that is, tends to *diminish* the angular displacement which must otherwise be observed. The action of the iron of the ring is, therefore, absolutely the contrary to that commonly attributed to it, for, so far from necessitating a displacement of the contact brushes in the direction of the rotation, it absolutely serves to diminish the angular displacement necessitated by the dissymmetry of the magnetic field." The explanation offered in exchange for that commonly received is, that the main line of force in the magnetic field is not the axial line between the poles N——S. The actual magnetic field, in any case, is, of course, a resultant of all the forces operating in it, and the presence of a magnetic body or an electric current at once deranges the normal lines of a field and sets up new conditions, in which the added force takes a part. It is calculated that the presence of the moving conductor, carrying a current, does in this way disturb the axis of the field, and change it from N——S to N⌒S; this ⌒-like distortion increasing with the velocity of rotation. The true line of commutation, being at right angles to the axis of the field, is, therefore, displaced more and more as the velocity of rotation increases; and it is contended that the iron, instead of causing this displacement, reduces it by concentrating the shortened lines of force upon its surface where closest to the poles of the field magnets. It would be interesting to know whether a Gramme ring without an iron core would really show greater displacement of the brushes than it does with the core.

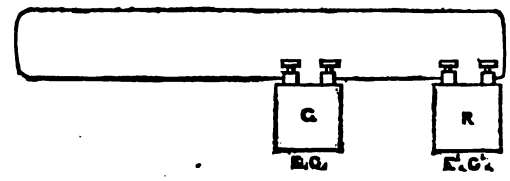
(TO BE CONTINUED.)

THE EDISON SYSTEM IN BRUNN.—We are informed that the Edison Company are starting a small lamp factory in Brünn, Austria, under the management of Mr. Francis Jehl, who, as our readers are aware, is in charge of the installation at the new theatre there.

THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.*

Ever since the experiments of MM. Chrétien and Félix at Sermaize, an account of which I gave to the Academy at its meeting on the 26th May, 1879, and those of M. Fontaine at the Vienna Exhibition in 1873, I have been endeavouring to find an installation by means of which I could ascertain all the electrical and mechanical *data* referring to the transmission of power by means of dynamo-electric machines. The varied conditions of the first experiments mentioned above were far different from those of the experiments which have for some time past occupied the attention of the Academy, and M. Marcel Deprez having requested me to be good enough to make the requisite calculations, I at once readily assented, the consequence being that I can now present to the Academy a very complete report of the experiments which took place on the 11th of February, the substance of which I am satisfied is accurate, and for which I assume all responsibility.

The telegraph wire of ·004 metre diameter over which the current was transmitted offered a resistance of 160 ohms; its total length, from Paris to Bourget, together with the return, was 17,000 metres (about 18,133 yards), but the other poles of the machines were connected by a short wire. (A diagram of the method of connecting the machines is given herewith.) The conditions of working, losses being taken into account, were comparable to a hypothetical case in which the two machines might be considered as situate, relatively to one another, at a distance of 8,500 metres only (about 9,066 yards), and connected by a double wire, lead and return.



Arrangement of Machines in M. Deprez's Experiments.

The generating machine, as far as its armature was concerned, was of a particular design introduced by M. Deprez, having a double bobbin and wire of 1 millimetre diameter ($\frac{1}{25}$in.); the receiver was a large Gramme machine, army type, modified for the work it was intended for. The resistances of these two machines were respectively 56 and 83 ohms. During each experiment the number of revolutions per minute made by each machine was determined simultaneously by means of special counters. All the electrical measurements were made by Dr. J. Hopkinson, F.R.S., with Sir William Thomson's apparatus. They agreed very exactly with the figures obtained previously by M. Deprez with the aid of his own apparatus.

The measurements of the difference of potential between the two poles of each of the machines were made with a Thomson galvanometer, a supplementary resistance of 50,000 ohms being employed. The current measurements were made by means of another Thomson galvanometer, through which the whole current was made to pass. The magnets of both these instruments, after having been tested in London on the 9th February, were again examined on the 13th February, on their return from Paris, and it was ascertained that they had undergone no change; each division of the potential galvanometer corresponded to 50·7 volts., and each division of the current galvanometer to ·223 ampere.

General Morin's dynamometer, with rotating dials, lent for the occasion by the Conservatoire des Arts et Métiers, was used for the measurement of the motive power, and connected to the generating machine by an intermediate shaft.

The experiments were made under conditions which showed that no slip to speak of had failed to be taken into account. The motive power was measured by diagrams in which each millimetre of ordinate represented an effort of 8·80 kilograms, the path travelled per revolution being $\pi \times \cdot 835 = 2 \cdot 623$ metres. The effective work at the shaft of the receiver was constantly measured by a Prony brake, perfectly balanced, the lever arm of which had a horizontal length L = ·796 metre, corresponding to a travel of 5 metres per revolution. This lever being uniformly weighted with 5 kilograms, the work was calculated on the basis of 5 kilogrammetres per revolution (about 36ft.-lbs.).

Seven successive experiments were made under the conditions above mentioned. Only one diagram—that of the last experiment—failed me; and, in addition, I measured the work ex-

* Report on the Results of the Experiments made by M. Deprez in the workshops of the Northern (of France) Railway, presented to the Paris Academy of Science by M. Tresca.

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TABLE I.—Giving data relating to all the experiments.

No. of the Diagrams.	Dynamometer.				Current	Generator.			Receiver.			Brake.
	Mean Ordinate of the Diagrams.	Revolutions per minute.	Work in kilogrammetres.	Motive power in h.-p.	In amperes.	E.M.F. in volts.	No. of revolutions per minute.	Electrical work in h.-p.	E.M.F. in volts.	No. of revolutions per min.	Electrical work in h.-p.	Work at the brake in h.-p.*
	mm.											
I.	12·87	101	500·07	6·66	2·523	1447	633	4·89	1037	418	3·50	2·32
II.	12·84	98	484·09	6·45	2·594	1324	596	4·61	936	369	3·26	2·05
III.	13·49	97	503·39	6·71	2·531	1237	608	4·19	887	384	3·01	2·13
IV.	12·48	92	441·70	5·89	2·564	1247	571	4·29	869	345	2·99	1·92
V.	13·01	87	435·43	5·80	2·564	1212	553	4·17	814	315	2·80	1·75
VI.	12·52	90	433·48	5·78	2·576	1276	580	4·41	908	363	3·14	2·01
Totals ...	77·21	565	2798·16	37·29	15·352	7743	3511	26·56	5451	2194	18·70	12·18
Averages	12·87	94·2	466·36	6·21	2·559	1290·5	590·2	4·42	908·5	365·8	3·12	2·03
VII.	*x*	104	*x*	*x*	2·645	1533	699	5·47	1146	502	4·09	2·75
VIII. ...	0·78	112	33·6	0·45	and for each revolution per minute ·3 kilogrammetre.							

* The corresponding speeds are those of the shaft of the motor.

TABLE II.—Amount of the work measured at different points of the installation.

EXPERIMENTS.....	I.	II.	III.	IV.	V.	VI.	Totals.	Averages.
	h.-p.	h.-p.	h.-p.	h.-p.	h.-p.	h.-p.		h.-p.
Motive power at the dynamometer	6·66	6·45	6·71	5·89	5·80	5·78	37·29	6·21
Power lost at the generator by difference	1·77	1·84	2·52 ?	1·60	1·63	1·37	10·73	1·79
Electric power leaving the generator	4·89	4·61	4·19	4·29	4·17	4·41	26·56	4·43
Power expended in the circuit (by difference)	1·39	1·35	1·18	1·30	1·37	1·27	7·86	1·31*
Electric power entering the receiver	3·50	3·26	3·01	2·99	2·80	3·14	18·70	3·12
Power lost at the receiver (by difference)	1·18	1·21	0·88	1·07	1·05	1·13	6·52	1·09
Power transmitted to the shaft of the brake	2·32	2·05	2·13	1·92	1·75	2·01	12·18	2·03
RETURNS.								
Of the generator (in electric power)	0·734	0·715	0·624	0·728	0·719	0·763	4·283	0·712
Of the circuit (in electric power)	0·715	0·707	0·721	0·697	0·670	0·712	4·212	0·706
Of the receiver (in mechanical power)	0·671	0·610	0·707	0·642	0·625	0·640	3·895	0·651
Between the two ends of the circuit	0·348	0·318	0·317	0·326	0·302	0·348	1·959	0·326

* The resistance of the line, calculated at 160 ohms for a current of 2·559 amperes, represents a work of 1·42 horse-power.

pended in mechanical transmission between the dynamometer and the generating machine by an eighth dynamometrical measurement. The speed was then greater than during the other experiments. However, I only deducted the work expended per revolution, so as to be able at once to calculate its influence in each of the preceding experiments. In Table I. are collected all the data, as well as the averages to be calculated therefrom. The mechanical work was calculated in horse-power on the basis of 75 kilogrammetres per second; but I should remark that the electrical work was calculated by Dr. Hopkinson from direct galvanometer measurements, and taking one horse-power as equal to 76 kilogrammetres. Despite the slight inaccuracy which results from this, it has seemed better to me to let the figures arrived at by the English observer stand without alteration.

Considering, first of all, the average of the first six experiments only, we see that 2·03 horse-power was transmitted with an expenditure of 6·21 horse-power at the shaft of the dynamometer, which corresponds to a return of ·327 horse-power. And this conclusion is abundantly corroborated on comparing the figures in the different columns. For a mean speed of 94·2 revolutions per minute at the dynamometer, the work of mechanical transmission, including the rotation of the generator when light, reached $·3 \times 94·2 = 28·26$ kilogrammetres, or ·377 horse-power, and the figure given above for the return is therefore raised to $2·01 : (6·21 - ·38) = ·345$; but I attach little importance to this correction, which is minimised by the impossibility of suppressing this supplementary work in ordinary cases, which would comprise at the least the mechanical resistance of the bearings of the generating machine. It is, however, more especially in the results obtained at different parts of the installation that I feel the greatest interest; these results are given in Table II. They are very easy of interpretation if I state the fact that each of the three parts of the installation gives a useful effect of about ·70. The resistances of the generator, the heat developed in it, the losses at the brushes and by sparking account for a loss of energy amounting to 30 per cent. Under the conditions of the experiment the heat developed in the circuit represented 30 per cent. of the electric energy put into it. Doubts might have been expressed as to whether some connection did not exist between the lead and return wires had not the wires been supported on posts throughout the whole distance, and it suffices to remark in this connection that the loss between the generator and the receiver was, on an average, equal to 122 kilogrammetres, which corresponds to 160 ohms, the total resistance of the circuit.

Finally, the resistances of the receiver, its brushes and sparking at its commutator also absorbed 30 per cent. of the electric work which was imparted to it. In round numbers, the useful effect differed about $·70^3 = ·343$.

In future it will be right to expect in all experiments of this nature measurements of the work which acts on each part of the transmitting apparatus. The means we possess for measuring electric energy are far ahead of those with which we can measure work or heat, and we would particularly call attention to the facility and certainty afforded by the use of currents in this connection.

Electrical units are now in perfect accord with mechanical units. In the *data* relating to the seventh experiment, which

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may be placed side by side with the preceding ones, we have only the following readings :—

	H.-P.
Electric work of the generator	4·64
Intermediate loss by difference	1·34
Electric work at the receiver	3·30
Intermediate loss by difference	·31
Work actually transmitted	2·79
Effective return of the circuit	·711
Effective return of the receiver	·843

The latter figure differs greatly from those comprised in the general table; but we may conclude without much danger of mistake from the ·711 given above, that the effective work transmitted, favoured by a notable increase in speed, would not have differed greatly from those which were measured directly.

Beginning with the resistances of the two machines when at rest, we can calculate the work lost in heat, and subtract from this again the supplementary work lost either by friction, sparking, or by possible increase of the electrical resistance during working. It will be sufficient for us to say that the total losses in the generator amounted to ·92 h.-p., and in the receiver to ·36 h.-p. This difference is explained by the relative smallness of the work which is called into play in the receiver, and its measurement, whilst completing the figures already given as to the different losses, renders an account of all the practical conditions of the experiments. I cannot finish without bearing testimony to the care and skill with which Dr. Hopkinson made his calculations.

Summing up, it may be stated that the power actually transmitted to a distance of 8·5 kilometres (about 5·28 miles) over an ordinary telegraph wire of 4 millimetres diameter, according to M. Deprez's method of connecting up the machines, represents a third of the motive power. If the current remained the same, and the resistance of the circuit were taken away, the corresponding effective work would be raised, according to these figures, to nearly one-half the motive power.

The experiment, under rigid supervision at all points, established the fact of the transmission of 2 h.-p., and in one case 2·79 h.-p., to a considerable distance. The foregoing results were obtained with a speed at the generator of 590 revolutions per minute. A further series of experiments, in which the electrical measurements were made under the supervision of my fellow-worker, M. Cornu, established an average speed of 814 revolutions. An account of these will be given at the next meeting, but I may say here that an examination of the figures taken at the higher speed, when 3·68 h.-p. was transmitted, shows that the return, allowance being made for the power absorbed by mechanical transmission to the generator and by its shaft, was raised at 890 revolutions to 42 per cent. instead of of 35, and without this allowance to ·33 in place of ·32.

(TO BE CONTINUED.)

IMPROVEMENTS IN DISTRIBUTING AND MEASURING ELECTRICITY, &c.

The following has been thought of more importance than to be passed over in our usual short abstracts. It is an abstract of a patent taken out by Dr. Hopkinson, F.R.S., on the 27th July last. It is numbered 3576. The specification, as will be seen, deals (1) with distributing, (2) with measuring electricity. One aim of the inventor is to ascertain the potential at the far end of the circuit, and for this purpose he uses a differentially wound galvanometer. The more important idea, however, is to minimise the quantity of metal required for conductors by a special arrangement of the circuits:—

"Many devices have been proposed and used for keeping the difference of potential between the terminals of dynamo machines constant, or for indicating when such potential deviates from its standard amount. When the electricity is to be used at a distance from the dynamo, and conductors of a sensible resistance are used, it is proper to maintain constant the difference of potential at the end of such conductors where the electricity is used and not at the dynamo itself. If E be the difference of potential of the poles of the dynamo, R the resistance of the conductors from the dynamo to the place where the electricity is to be used, and C the current, it is necessary to maintain not E constant but E − C R, which is equal to the difference of potential of the two conductors at their other end. This is attained by using a differential regulating or indicating apparatus, as shown diagrammatically in Fig. 1. A is the dynamo machine, with lamps all placed near each other, connecting the conductors, but remote from A. The indicating apparatus is wound with a coil of thin wire making many convolutions. This coil is connected to the poles of the dynamo electric machine at E and F, and is, therefore, a shunt to the circuit. The indicating apparatus is also wound with a thick coil through which the whole current may pass, or a proportional part thereof, from G to H, the direction of the current in the thick coil being opposite to that in the thin coil, as indicated by the arrows. It is preferred to use a proportional part of the current through the thick coil, as it is then easy (by properly adjusting the resistance) to secure that, for the particular value of R which occurs, E − C R shall be constant. It is best to make the thin coil of German silver as it is important that its resistance shall not vary

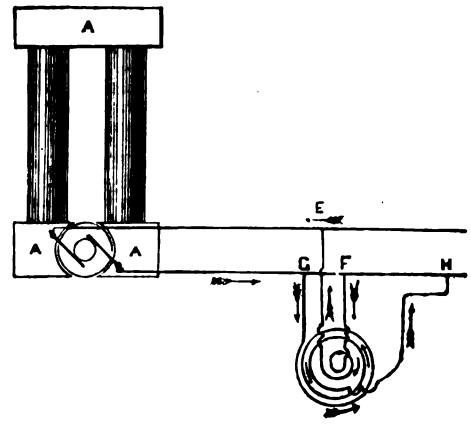

FIG. 1.—Diagram of Differential Regulating Apparatus.

sensibly. Fig. 2 shows how the differential instrument may be arranged to act as a relay. A B are the coils of thick wire, and C D the coils of thin wire, both wound on the same cores, the preponderating effect of the thin wire being opposed by the spring E attached to the movable armature G, carrying the contact piece F, which makes contact with H or I, according as E − C R is too great or too small, and so closes the circuit of one or other of two electric bells, or of other apparatus for indicating or regulating. The application of this instrument to an extended system of electrical supply with a network of distributing mains is important. For each machine a pair of feeders are provided, of a size appropriate to the current they are to carry, but independent of the distance they have to go. Each pair of feeders goes to, and is connected to, some part or other of the system of distributing mains, and by the use of this invention the difference

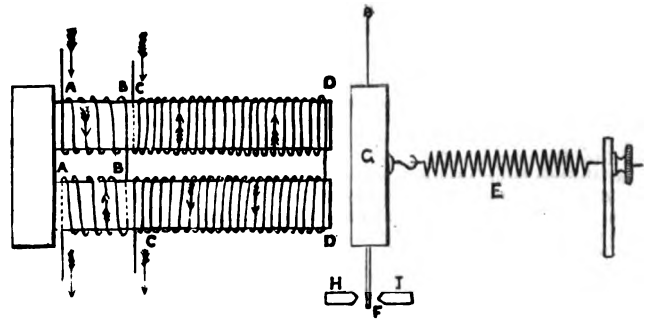

FIG. 2.—Showing how the Differential Arrangement illustrated in Fig. 1 may be made to act as a Relay.

of potential is kept constant at or near the point where the feeders join the distributing mains."

We shall give that portion of the patent dealing with Dr. Hopkinson's method of combining a comparatively high potential in the conductors with a low potential in the houses of a circuit, and also his measuring apparatus, in our next issue.

ELECTRIC LIGHTING AND THE BOARD OF TRADE

The following letter from Mr. Arnold White, secretary of the Edison Electric Light Company, appeared in *The Times* of March 24:—

"Sir: The draft Provisional Order issued by the Board of Trade bears evidence of a strong desire to facilitate the introduction of electricity into streets and houses for general purposes. At the same time, there are certain essential points for which no provision is made, and restrictions imposed which, in the opinion of the electric lighting companies, must inevitably act contrary to the intentions of the framers of the Act.

"This being entitled an Act to facilitate electric lighting, &c., it is assumed that anything which seriously hampers or prevents the spread of this method of illumination will, unless good reason is shown to the contrary, receive effective consideration by the Government and by the department. When Mr. Chamberlain was settling the amendments to the Bill introduced in the House of Lords it was resolved—first, that the electric companies should not prescribe their own or any form of lamp; and, secondly, that the charge to the consumer should be, not for light or for work done, but for electricity. Now, electricity used in a commercial sense is almost a metaphysical term. It cannot be stored, delivered, or measured except in the act of performing work. This being so, it would seem the natural course for the electric companies to base their charges not on the number of ampere hours registered by the meters, which the public do not understand, but on the light supplied or the power used by customers, which provides a unit that the public do understand. But there is a stronger reason for this method of charge in the interests of the public, of the local authorities, and of the electric companies. The Act as it stands is an Act for the perpetuation of bad lamps, and consequent obstruction to economical improvements. At the present time the most economical lamp known requires about ·75 of an ampere of electricity to produce 16 candles of light for a period of one hour.

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To-morrow a lamp might well be invented which will produce the same amount of light with a consumption of half the quantity of electricity. Under the Act there is no incentive given to the companies or to inventors to supply a more economical lamp, because the only effect of so doing would be that the amount of electricity sold would be less with the better and more economical lamp than is the case with the obsolete and more wasteful lamp. This is a blot so great, that unless the methods of charge are revised in such a way as to promote the use of good and economical lamps, the progress of electric lighting will be inevitably hindered in this country. This is as if in the early history of the gas enterprise artificial restrictions were imposed on the invention of more economical methods of consumption.

"In the determination to act in a fair spirit, Mr. Chamberlain resolved that the companies should not prescribe what lamp should be used within the areas supplied by them. Now, a lamp is as much a part of an electric system as the dynamos or the conductors. In fact, the lamp, the dynamo, and the conductors must be correlative, otherwise both economy and safety may be jeopardised.

"In the parallel system adopted by the Board of Trade the size of the conductors for a given number of lamps is determined by the specific relation between the resistances of the lamp and dynamo respectively. The higher the resistance of one, and the lower the resistance of the other, the smaller may be the conductors. As, for example, in the Edison system, the lamp has 140 ohms resistance when burning, and the dynamo machine but 3-1000 of an ohm. The wires, therefore, for a given number of lamps may with safety be very small. Supposing a consumer were to introduce upon his premises, provided with conductors for such lamps, one of the many other forms of lamps of lower resistance and economy, the conductors would then be inadequate, and a consequent loss of energy and increased risk of fire would ensue.

"These considerations lead to the question of the provisions proposed by the Board of Trade for testing the current on the mains by a parochial electric inspector. The companies are strongly of opinion that any tests made should, in the interests of the public, consist of an examination and test of the light supplied, and not of the methods of producing that light. The only object of testing the current would be to see that the potential is not beyond the safe limits prescribed by the Board of Trade. The Edison system, for example, will enter the house at a pressure of 110 volts. If the pressure be greater than this, the lamps would burn out, and the company would lose their custom. If the pressure be lower than 110 volts, the lamps would burn at a dull red, and the company would likewise suffer the loss of its custom. Moreover, one of the cardinal points on which the Edison system rests is the continuance of the current on the mains day and night, without the intermission of a single minute for testing. The tests are made while the current is on the mains. The instruments for doing this are the invention of Mr. Edison and his assistants, and it is not likely that the parochial electric inspector of the future will possess the qualifications either to invent the instruments or to use them when invented, unless he is taught to do so by the Edison Company. The inspectors appointed under the Adulteration Acts are, no doubt, well fitted for the purposes for which they are employed, but the inspection of a great electric light system is a much more difficult matter, and one that would be better undertaken by the skilled officers of a Government department, carefully selected, than by a parish authority, who has everything to learn on the subject, elected by an elective vestry. It is necessary to speak plainly in this matter, and the companies' view of the parochial electric inspector of the future is that while the public will not be benefited by any inspection or testing of the current, it would be benefited by a photometrical inspection of the light supplied and a record of potential at the central station and at various points throughout the districts being furnished either to the Board of Trade or to the parish authorities."

THE EASTBOURNE ELECTRIC LIGHT COMPANY.

The second ordinary general meeting of this Company was held at Eastbourne, on Saturday, the 17th inst., Mr. G. Boulton in the chair. After the usual preliminary business,

The CHAIRMAN said a copy of the report and the accounts had been sent to each shareholder, and, he presumed, they would be taken as read. From the latter it appears that in the capital account the capital received on 491 shares was £4,910; when the payment for machinery and plant, rent, salaries, &c., amounted to £4,000 8s. 6½d., leaving a balance on capital account of £909 11s. 5½d. The assets and liabilities on capital account showed assets: £2,269 11s. 5½d; liabilities, £4,014 1s. 8d. From the revenue account it appears that the receipts were £744 12s. 3d., including £507 10s. 5d., the balance charged against capital, to be reimbursed out of revenue: and the payments were an equal amount. From the report it appears that the income of the Company from public and private lighting now working amounts to £1,306 per annum, which is sufficient to cover all the present working expenses.

The CHAIRMAN (continuing) said it was his duty to move the adoption of the report and accounts of the past year. He thought, looking at the satisfactory nature of the report, he had a very light duty to perform. He did not know that he could say more than the report said for itself. Within twelve months they had lighted a great portion of Eastbourne, and had contracts for lighting up other parts of the town. With a view of introducing the incandescent system of lighting they had taken Mr. Gosden's brewery in Junction-road. They had received many applications for incandescent lamps; and the directors firmly believed that if the incandescent system of lighting were introduced the Company would be able to make a large profit, and to pay a good dividend. But at present they had not sufficient money to start it. Before starting such a system they must have more capital. They could light with their present capital and plant many more arc lamps than were being worked at present: and as they were paying the working expenses every additional arc lamp they worked would mean new profit for the shareholders. But, he was afraid, they would not make sufficient profit out of arc lighting alone to pay such a dividend as they should like to receive. And, therefore, the directors wanted permission to issure more capital—say from £3,000 to £5,000 to enable the Company to start a system of incandescent lighting. The engineer had reported to him that during the year eight and a-half miles of cable had been laid in just over four miles of pipe or tubing. They had now 36 lamps, and a contract with the local board for seven others, which would make altogether 43 lamps. They had also entered into a contract with the Waterworks Company to light up their new engine house.

The report and balance-sheet were adopted.

THE WESTERN AND BRAZILIAN TELEGRAPH COMPANY (LIMITED).

An extraordinary general meeting of this Company was held on Thursday at St. Michael's Hall, George-yard, Lombard-street, E.C., Sir Henry Drummond Wolff, M.P., in the chair.

Mr. R. M. CUNNINGHAM (the secretary) having read the notice convening the meeting,

The CHAIRMAN said the object of the meeting was to confirm the resolutions passed at the previous meeting, and he had very little to say, except that Mr. Price had written to the directors to say that he still retained his opinion with regard to the desirability of not dividing the shares in the manner proposed. It might be satisfactory to the shareholders to know that the traffics were still going on very satisfactorily.

Mr. HERRING then moved the confirmation of the resolutions passed at the previous meeting, having for their object the division of the shares into preferred and deferred shares.

Mr. SUTTON seconded the motion.

Mr. PRICE said that when this matter was originally proposed all the shareholders at the meeting excepting three supported him in his opposition to it. The effect of the division of the shares would be to lead to very wide speculation, and it would lead to unfair transactions taking place. In the cases of Brighton "A," South Eastern "A," and Sheffield "A," any one could see the violent fluctuations that took place on the Stock Exchange, and that led to the detriment of the companies, and to the boards of directors, who managed them. In many cases inferences were drawn that some charges which ought to go against dividend were put off, or, on the other hand, some charges were put to revenue which ought not to be. He asked what advantage it would be to the Company to divide their shares. They were not increasing the capital of the Company one *iota*; they were not adding to the revenue of the Company one *iota*, and were doing no good to the Company, but, in fact, injuring it, whilo the operation would increase the clerical work of the office by 200 per cent.

Dr. GUESDON pointed out that the effect of the operation would be to reduce the qualification of the directors, and having referred to the number of shares held by the Board, he moved an amendment having for its object the decreasing of the voting power of the deferred shareholders.

The amendment, however, fell to the ground for want of a seconder.

The resolution was then put and carried, six voting for and two against it.

The CHAIRMAN having mentioned that the Board held a large number of proxies, the proceedings terminated in the usual manner.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES MAR. 28.		BUSINESS DONE WEEK ENDING MAR. 28 Highest.		Lowest.
Anglo American	51,	5¼	51¼		51¼
Do. Preferred	83,	84	83¾		83
Do. Deferred	20½,	21	20½		20½
Brazil Submarine	12¾,	12¼	12¾		12 7-16
Cuba	9¼,	10¼	—		—
Do. Preference	16½,	17½	17½		17½
Direct Spanish	5½,	6	5¾		5¾
Do. Preference	15½,	16½	--		—
Direct United States Cable	12½,	12¾	12 13-16		12¾
Eastern Telegraph	10¾,	11¼	11		10¾
Do. 6 per Cent. Preference	13,	13¼	—		—
Do. 5 per Cent. Debentures, 1899	104,	107	—		—
Eastern Extension	11¼,	11¾	11 13-16		11¼
German Union	10½,	11	10½		10½
Globe Telegraph and Trust Company.	6¼,	7	7		6 13-16
Do. Preference	12¾,	13	13		12 13-16
Great Northern	12¾,	12¾	12¾		12¾
Indo-European	32½,	33½	—		—
Mediterranean Extension	1¼,	2	1¾		1¾
Do. Preference	6¼,	7¼	—		—
Reuter's	10½,	11	—		—
Submarine	247,	252	—		—
West India and Panama	1¾,	1¼	—		—
Do. 1st Preference	7½,	8	7¾		7¾
Western Brazilian	7¼,	8¼	8		7 15-16
West. Union 7 per Cent. 1st Mortgage	122,	126	—		—
Do. 6 per Cent. Sterling Bonds	102,	105	—		—

TELEPHONES.

Consol. Telephone and Maintenance	¾,	1¼	1¼		1
Oriental	¼,	¾	¾		¾
United Telephone	10½,	11	10¾		10¾

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	6¼,	7	6¾		6¼
Do. (fully paid)	9,	10	—		—
Hammond Light	3¼,	4	3 9-16		3¼
Eastern Electric (fully paid)	—,	—	—		—
Pilsen, Joel, and General Electric	¾,	1	—		—
Swan	1¾,	2¼	2 1-16		2
Maxim-Weston	¼,	¼	—		—

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SLIP

ELECTRICITY IN OUR HOMES.—The first of a series of articles on this subject, from the pen of Mr. John Munro, will be found in this month's *Good Words*.

REPAIR OF THE DIRECT SPANISH CABLE.—The Direct Spanish Telegraph Company's cable communication with Spain, *viâ* Bilbao, is now again fully restored.

TO BE WOUND UP.—A petition was to be heard before Mr. Justice Fry, on Friday, the 16th inst., for the winding up of the Electric Light Syndicate, whatever that may be.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of March, 1883, amounted to £32,970, against £33,677 in the corresponding period of 1882.

ELECTRIC LIGHTING FOR LEWISHAM.—The Jablochkoff Company have asked permission of the Lewisham District Board of Works to their obtaining a license under the Electric Lighting Act.

THE ROYAL SOCIETY.—At the meeting of this society on Thursday last the following paper was to have been read by Professor Horace Lamb, viz.:—"On Electrical Motions in a Spherical Conductor."

CHINESE TELEGRAPH RATES.—The *Journal Télégraphique* announces that the Chinese Government have recently raised the tariff for telegrams between Shanghai and Nankin, from 1·40 francs per word to 1·50 francs.

TASMANIA.—The Industrial Exhibition was opened at Hobart on February 6 by the Governor with much ceremony. The building, which was crowded at night, was illuminated by the Brush light.—*Colonies and India.*

NEW COMPANY.—A company has been formed in Newark, New Jersey, U.S., under the title "The American Electric Storage Company," to work the patents of Mr. Nathaniel S. Keith, of New York, for storage batteries.

DIRECTORSHIP OF SPANISH TELEGRAPHS.—Senor L. del Rey has been appointed Director-General of Posts and Telegraphs in Spain, in place of Senor Candio Martinez, who has been promoted to the office of State Counsellor.

SUBMARINE CABLES TRUST COUPONS.—The Submarine Cables Trust give notice that the coupons due on the 15th inst. will be paid on and after Monday, the 16th instant, by Messrs. Glyn, Mills, and Co., 67, Lombard-street, E.C.

SOCIETY OF TELEGRAPH ENGINEERS.—The next meeting will be held at 25, Great George-street, S.W., at 8 p.m., on Thursday, the 12th April, when a paper will be read "On Microphonic Contacts," by Shelford Bidwell, M.A., LL.B.

HONOURS FOR A TELEGRAPHIST.—The *Gazette* announces that the Queen has given directions for the appointment of Mr. Charles Clarke, Chief of the Egyptian Telegraph Department, to be a Companion of the Order of St. Michael and St. George.

PERSIAN TELEGRAPHS.—The Indo-European Telegraph Company state that, the cables of the Indian Government in the Persian Gulf being now restored, they are prepared to accept messages for transmission between this country and India, China, &c.

ELECTRIC LIGHTING AND THE HAMPSTEAD VESTRY.—The Hampstead Vestry have called in Mr. Williams, of Palace-chambers, St. Stephen's, to report and advise on the provisional order applied for by Messrs. Ferranti, Thomson, and Ince for that district.

THE MAXIM-WESTON ELECTRIC COMPANY.—We understand that this company have contracted with the Science and Art Department to light Bethnal Green Museum throughout, also with the contractors for the Tilbury Dock Works, to enable them to work continuously by night and day.

ELECTRIC LIGHTING IN RESTAURANTS.—The Electric Light Supply and Fitting Company are installing 80 Swan lamps in Messrs. Browne and Martin's restaurant in Dacre-street, Westminster, S.W. The current is supplied by a vertical Franklin dynamo, driven by one of E. R. and F. Turner's engines.

THE TELEPHONE IN NOTTINGHAM.—The Watch Committee of the Corporation of Nottingham have instructed Mr. Fry, manager of the National Telephone Company's Exchange in that town, to erect a series of fire alarms at various points. Several have already been erected; they communicate with the station and the fire stations.

THE NEW ARMY TELEGRAPH CORPS.—It is stated that the commanding officer of the 24th Middlesex Rifle Volunteers (Post Office Corps) is asking for men who have had experience in artillery and cavalry regiments, to act as drivers to the recently-acquired telegraph van. This completes the equipment of the Postal Telegraph Corps, which now numbers more than 150 men.

ELECTRIC BELLS.—Mr. Gent, of Leicester, is exhibiting at the Building Exhibition now being held at the Agricultural Hall a new method of arranging the electro-magnets of electric bells, by means of which he obtains more power with a given current. Mr. Gent's plan consists in placing the electro-magnets horizontally and the armature above them, instead of at the side and at an angle, as is usually the case.

ELECTRIC LIGHTING IN PARIS.—On the occasion of the annual *conversazione* of the French Physical Society, the rooms of the Society of Arts, where it was held, were brilliantly illuminated by means of Edison and Swan lamps and accumulators. The transmission of power was also illustrated by means of a Gramme machine, which was supplied with current by accumulators. These latter were supplied by the French Electrical Power and Storage Company. M. Trouvé also exhibited some of his new bichromate of potash batteries at work.

THE EDISON SYSTEM IN PARIS.—*L'Electricité* says:—"On the 20th March M. Louis Rau, manager of the Société Edison, gave a brilliant reception in his *salons*. Edison lamps replaced candles and gas burners throughout. On the commencement of the *cotillon* towards 2 a.m., each of the lady dancers was presented with a bouquet, in the middle of which shone an incandescent lamp. After a mazy valse, the bouquets were deposited on a daïs, where they formed a grand constellation of flowers and light. The lamps were fed by means of batteries devised by M. Trouvé."

THE EASTERN EXTENSION TELEGRAPH COMPANY.—This company state that their accounts to the 31st of December last show, subject to audit, a balance of profit of £109,355, after payment of three interim dividends and a bonus for the first half of the year. The directors now propose to pay on the 18th inst. a final dividend of 2s. 6d. per share, together with a bonus of 2s. per share (both free of income-tax), making, with previous distributions, a total payment of 6½ per cent. for the year 1882. A balance of £64,411 is to be carried to the reserve fund, which now stands at £351,133.

TELEPHONIC EXTENSION IN FRANCE.—A telegram from Paris, dated Tuesday, states that telephonic communication is receiving rapid development there. From the 1st of July

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next telephones will be annexed to all telegraph offices in Paris, and the chief ones in the provinces, as well as at the leading railway stations. The charge to those using them will be 25 centimes, and for this sum five minutes will be given for the reception and transmission of messages. The apparatus will be established in private residences at an annual subscription of 170 francs in Paris, and 200 francs in the provinces, about £7 and £8 respectively.

Arrest of a Company Promoter.—A Reuter's telegram from Paris, dated April 4, says:—"At the request of the Belgian Public Prosecutor M. Simon Philippart was arrested here yesterday on a charge of falsifying the accounts of his bank. The Belgian Government has demanded his extradition." Another telegram says:—"M. Simon Philippart, who has lately promoted several electric lighting companies, has been arrested at his office in the Avenue Opera, at the instance of the Brussels authorities, who demand his extradition on a charge of forgery and of having obtained money by fraudulent pretences. The preliminaries necessary before his surrender are now being proceeded with."

Electric Lighting at Brighton.—On the occasion of a fancy dress ball, held in aid of the Brighton *crèche* on Wednesday last in the Pavilion, the banqueting hall, in which the dancing took place, was lighted throughout by Swan lamps. The lighting was carried out by Mr. Magnus Volk, who has been entrusted with the work of extending this means of illumination throughout the whole building as a permanency. He has made such progress with the "wiring" that it is hoped the lighting will be completed in about three weeks time. Swan lamps will be used throughout, the current being supplied by a Siemens dynamo. The power will be afforded by a Robey semi-fixed engine, situate in the Corporation Yard.

The Edison System in the House of Commons.—The Edison installation at the House of Commons started running this week. The lights are distributed throughout the dining room and library. Sixteen electroliers, each containing a group of sixteen lamps, are in use, the current being supplied by two 250-light "K" dynamos, similar to that illustrated in our issue of the 24th ult., p. 441. The lamps can, if necessary, be fed by one ot these machines should any accident incapacitate either of them. The dynamos are driven by an Armington and Sims engine, of similar make to that described in our issue of the 24th ult. A cable, 150 feet long, runs from the engine room to the lamps. We wish the company every success with their contract, which, we understand, lasts till the end of the Session.

Electric Lighting and the Czar's Coronation.—*The Times'* correspondent telegraphs from St. Petersburg under date March 30, as follows:—"At Moscow the preparations for the coronation are making rapid progress. For four nights the great belfry tower of iron was splendidly illuminated by electricity by way of an experiment. No fewer than 4,000 Swan incandescent lamps cover the cupola, and 120 electric lamps of Russian invention outline the cross. All the principal churches are also to be illuminated with ordinary lights from foundation to spire. The assistance of foreigners in the work is to be entirely dispensed with if possible; and no English illuminating or pyrotechnic firms will be employed on this occasion, as they were at the coronation of Alexander II. The firework displays are to be conducted by artillerists and engineers, independently of all extraneous aid."

The Simoom and Dust Storms.—In a paper recently read before the Meteorological Society, Dr. H. Cook, F.R.G.S., described the dust storms which take place in Beloochistan, North-west India, and stated that he considers them to be due to an excess of atmospheric electricity. With regard to the simoom, which occurs usually during the hot months of June and July, it is sudden in its attack, and is sometimes preceded by a cold current of air. It takes place at night as well as by day, its course being straight and defined, and it burns up or destroys the vitality of animals and vegetable existence. It is attended by a well-marked sulphurous odour, and is described as being like the blast of a furnace; and the current of air in which it passes is evidently greatly heated. Dr. Cook believes it to be a very concentrated form of ozone, generated in the atmosphere by some intensely marked electrical condition.

The Wire Question in America.—We take the following items of information from the *Sanitary Engineer*:—"The City Councils of Philadelphia, on the 15th ult., amended the ordinance to permit the Baltimore and Ohio Telegraph Company to place wires through the city, so that the company is required to lay the wires underground in the built-up portions. The mayor has made it known that he will veto any ordinance granting the right to erect poles in the streets.—Captain F. U. Greene (U.S. Engineers), after inspection of systems of underground electric wires in Boston and New York, is in favour of prohibiting the further erection of poles in Washington. He recommends that experiments be made with the fire alarm wires to test an underground system less expensive than those now usually employed, and he recommends that estimates be submitted to the next session of Congress for placing all fire alarm wires underground, and a Bill be prepared compelling all electric wires to be put underground at an early date.

Electric Light in an Indian Mill.—The Egerton Woollen Mills, lately erected at Umritsar, Punjaub, have adopted the electric light for their premises. The installation consists of a 16-light Brush dynamo machine and 16 arc lamps, throughout the mills and compound. The installation is very successful. The looms, carders, and other machinery are well lighted. The natives admire the light very much, and call it "Bidjerley" lightning. They are able to work all night with perfect ease, and are arranged in two gangs, one gang working from 1 p.m. to 10 p.m., and the other from 3 a.m. till 12 noon. All colours of the wools are perfectly seen. The power is obtained from a Bolton turbine. The water is diverted from a canal near, and afterwards used for irrigation purposes. The cost of maintainence for the lights, therefore, is—carbons and wages of a native to trim the lamps and attend machines, 10 rupees per month (16s.). A saving is also effected on insurance. The work was carried out by the Eastern Electric Light and Power Company, under the superintendence of Mr. E. W. Lancaster, engineer in charge, who successfully carried out the lighting at Rupar, on the opening of the Sirhind canal by H. E. the Viceroy.

Electrical Engineering in America.—We take the following from the *New York Mail and Express* of March 16:—"In reviewing the report of the plans of the Columbia College authorities the other day, reference was made in these columns to a school of electrical engineering, which President Barnard said was needed to extend the scope of the college. On Tuesday of this week a meeting of the committee appointed to consider the project was held, Mayor Low, of Brooklyn, being the chairman, and definite plans were proposed for the immediate establishment of such a school. Estimates had been obtained from Mr. Edison as to the cost of the necessary 'plant,' and it was said by

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that gentleman that 15,000dols. would cover the first cost. After that the school could be kept up for 25,000dols. a year. It is proposed to ask the different telegraph and telephone companies to supply the plant and contribute 12,000dols. a year to the support of the school, which would be of great help to them in furnishing, what is now difficult to get, trained electrical engineers, such as they need for the successful operation of their business. In case this request is granted by the companies the school will at once be established, the present professors taking a share of the work, and new professors being engaged so far as necessary. We hope the committee will be successful. Such a school is needed, and its establishment would be a good beginning in the building of that great university at which the college authorities are aiming."

Charing-cross and Waterloo Electric Railway.—The prospectus of a company which has been formed with the above title has just been issued. The proposed capital is £100,000 in £10 shares. The object of the undertaking is to construct and work an electric railway from Charing-cross to Waterloo, a Bill for which was recently obtained, as mentioned in these columns some weeks since. The line will pass under the Thames through iron caissons. The work of construction will commence near the northern end of Northumberland-avenue, opposite the Grand Hotel, and be continued through an arch under that avenue and the Victoria Embankment. Of that arch sixty feet under the Embankment have already been constructed. The railway will pass under the Thames, and again through an arch under College-street and Vine-street, and terminate at Waterloo Station, where it will be directly connected with the platforms of the London and South Western Railway, with a separate approach from the York-road. The line will be double, and worked by means of a stationary engine at Waterloo, transmitting the power to the carriages, which will run separately, start as filled, and occupy about 3½ minutes in the journey. A tender has been accepted for the construction of the railway, to be ready for opening within eighteen months from the commencement of the work. A contract has also been made with Messrs. Siemens Bros. and Company to provide and erect all requisite electrical machinery, rolling stock, and apparatus not included in the before-mentioned tender. Messrs. Kellett and Bentley have the contract for the line for the sum of £80,000.

Legal.—The Brush and Gramme Dynamo.—On Wednesday last, before Mr. Justice Watkin Williams and Mr. Justice Mathew, in the case of the British Electric Light Company and the Electric Power Company *v.* the Anglo-American Brush Electric Corporation, Mr. Moulton moved on behalf of the defendants on appeal from an order of Mr. Justice Hawkins, made at Chambers, affirming one made by a Master refusing to order the plaintiffs to give security for costs. The learned counsel said he relied upon an affidavit made by Mr. Cordner, the general manager of the defendants, who stated his belief that neither of the plaintiff companies had any assets available for the payment of the costs of this action in the event of the verdict being in favour of the defendants. Mr. Cordner's affidavit was, further, to the effect that the Electric Power Company had a capital of 5,007 shares of £10 each, of which all but seven had been fully paid-up, and that he believed they were without either property or assets to answer the costs of this action; that the British Electric Light Company had a nominal capital of £100,000, in shares of £10 each, of which, on July 27, 1882, 7,221 had been issued and fully paid-up, with the exception only of a sum of £610, due on calls not paid. Mr. Cordner also swore that he had been informed and believed that the British Electric Light Company (Limited) were carrying on this action by the aid of funds subscribed by their shareholders and others. The learned counsel said that the costs of the defendants had already amounted to £1,800, and would amount to a further sum of at least £2,000, as the litigation, involving, as it did, the whole question of the patent rights in dynamo machines, must necessarily prove to be of the most expensive character. The Court dismissed the appeal, with costs, without calling upon Mr. Carpmael, who appeared for the plaintiffs.

Electric Lighting for Dundee.—The following is some further information which has been made public with reference to the lighting of Dundee by means of Brush lamps:—At a special meeting of the Dundee Gas Commissioners, held a day or two since, Provost Moncure explained that the first condition of an agreement that had been come to between a committee of the commissioners, when recently visiting London, and the Brush Company, was that the order promoted by the Gas Commissioners for lighting the town should be withdrawn. By the other conditions the Brush Company would get four years to make experiments; but if they did nothing in that time in the way of erecting works and getting apparatus for lighting the compulsory area, then their order would entirely lapse. This would secure the making of experiments without the commissioners being put to any expense, and if experiments were made in the four years, then the order would extend over 15 years, instead of 21 as in the Bill. After that period had elapsed, the company were obliged to dispose of their works to the Gas Commissioners if the latter desired them, and on the terms laid down in the Commissioners' Act. If the Gas Commissioners did not want then to purchase the works, the company would go on and supply the light for seven years, when the commissioners would have the opportunity of again purchasing if they desired. If no purchase was made, then the company would go on supplying the electric light, but with a similar break at the end of each seven years. It was also a condition that the company would light the streets when requested by the Police Commissioners, on terms to be agreed upon. The Gas Commissioners considered the terms of the agreement very favourable, as it prevented monopoly, and gave the commissioners an opportunity to step in at any time and take the lighting into their own hands. The agreement was approved of, and remitted to the committee to get it carried out.

On the Material Particles in Electric Sparks.—We take the following abstract of a paper by Dr. Friedrich Wächter, in the "Sitzungsberichte der kaiserlichen Akademie der Wissenschaften," Vol. LXXXV., March, 1882, from the abstract of papers in *Foreign Transactions*, &c., published by the Institution of Civil Engineers.—"In two former communications to the Vienna Academy, Professor Reitlinger and the author had endeavoured to prove that the glowing particles of the electrode, which constitute an electric spark, emanate entirely from the positive electrode. On the other hand, the experiments of Plücker, Gassiot and others, show that, under certain circumstances, the loosening and projection of the particles takes place at the negative electrode. The object of the present paper is to discuss this apparent inconsistency, and to consider the difference between the electro-positive and electro-negative loosening of the particles of the electrode. Only the discontinuous sparks produced by a friction machine, or by the secondary circuit of an induction coil, are considered, the formation of a continuous electric arc by the heated particles of the positive electrode

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being well known in the case of galvanic currents generated by a dynamo machine or ordinary battery. It has generally been stated in text books that sparks produced electro-statically possess the same characteristics, whether the discharge be of positive or negative electricity; but the study of Priestley's ring figures, Lichtenberg's figures, and the deflection of the particles by a powerful magnet, show conclusively that the two phenomena are distinct, and marked by essential differences. The author summarises the results of his investigations on discharges through a gaseous medium briefly as follows:—1. The projection of the anode particles takes place in atmospheric air under a pressure of 4,500 to 10 millimetres of mercury; the projection of the particles of the cathode could only be observed for pressures varying from 63 to 0·005 millimetre. 2. The quantity of particles loosened from the electrodes, in equal times and under similar circumstances, diminishes with decreasing atmospheric pressure for the anode, but increases for the cathode. 3. The anode-particles are projected considerably further than the cathode-particles under the same conditions. (In the case of a pressure of 63 millimetres, about 3,400 times as far.) 4. The anode-particles, uninfluenced by the pressure of the air, always proceed from a relatively small surface; the cathode-particles, on the other hand, are projected from a surface always increasing in area as the pressure diminishes. (The area in the latter case reaches as much as 10,000 times that in the former.) 5. The anode-particles leave always from a determined position on the anode, viz., the point lying nearest the cathode; whereas the cathode-particles proceed from the whole surface of the cathode. 6. The projection of the anode-particles is favoured by an electrode bent or pointed in form; the projection of the cathode-particles by a clean surface, free from oxidation. 7. The direction of motion of the anode-particles is determined by the relative position of the cathode, since they move towards the cathode in the direction of the current along the line of least resistance. The cathode-particles always proceed normally to the cathode surface, uninfluenced by the relative position of the anode and the direction of the electrical current. 8. The anode-particles can move in all conceivable curved paths, while the cathode particles describe straight lines, and are not capable of moving in a curved line. 9. The anode-particles are deflected by a magnet, as if they were diamagnetic substances; the cathode-particles are affected like paramagnetic bodies. 10. The anode-particles are transferred both in a luminous and non-luminous condition; the cathode-particles only in a non-luminous condition. 11. The anode-particles are of measurable size, and are apparently loosened by some mechanical impulse; the cathode-particles are indefinitely small, and seem to originate from a process of vaporisation. 12. The projection of the cathode-particles is certainly promoted by warming the electrode, whereas this cannot be asserted with safety with regard to the anode-particles. 13. The cathode-particles are the vehicles of the electric current from the electrode to the molecules of the gaseous medium. This is not the case with the anode-particles. 14. From the experiments of Wiedemann and Rühlmann, it appears that a greater electrical tension is necessary for the projection of the anode-particles than is required for the cathode-particles. These facts prove, in the opinion of the author, that the difference between the two kinds of electricity cannot be successfully explained by the assumption of a reversal of conditions, which can be expressed by plus and minus, but involves an essentially qualitative change."

THE MEASUREMENT OF ELECTRICITY.—This was the title of a lengthy paper read by Mr. J. N. Shoolbred, M.I.C.E., before the Society of Arts, on Wednesday evening last. Dr. C. W. Siemens, F.R.S., occupied the chair, and the audience was a large one. The paper of necessity went over a good deal of old ground, and described a number of meters which have already been dealt with in our columns; we shall, therefore, content ourselves with giving the more salient points of Mr. Shoolbred's communication, leaving those of our readers who care to do so to fill up the gaps by consulting the *Journal of the Society of Arts*. Having defined the terms, "electricity," "magnetism," and "electro-magnetism," Mr. Shoolbred passed on to the various units, and the manner of their adoption. When speaking of the unit of "price," which the Board of Trade suggest should be based on the energy contained in a current of 1,000 amperes flowing under an electromotive force of one volt during one hour, or, in other words, 1,000 volt-ampere-hours, Mr. Shoolbred said:—"The ampere-hour is another way of saying 3,600 coulombs of quantity of electricity supplied. It may also be of interest to state in other, and perhaps more conventional, terms the equivalent of the amount of work implied in the above unit.

Work done, or Energy Expended.

1,000 volt-ampere-hours =
- 10^{10} erg hours.
- 3,600,000 volt-coulombs.
- 3,600,000 joules.
- 1,000 watt hours.
- 2,645,000 foot-pounds.
- 366,840 kilogrammetres.
- 1·35 force cheval-heures.
- 1·34 horse-power hours.

Put in terms more in accordance with actual practice, the above unit might mean the supply for one hour of a current of 10 amperes with an electromotive force of 100 volts, or of a 5-ampere current with an E.M.F. of 200 volts; or, again, a 10-ampere current at 200 volts for only half an hour, and so on, provided that the product of the three factors is always 1,000." The author then dealt with the instruments required to measure electric energy, and stated that it was only such as were "furnished with means for continuously integrating or recording the successive progressions of the supply, or instruments to which such recording apparatus can readily be attached," that came properly within the scope of his paper. There must, Mr. Shoolbred insisted, be a continuous record both of the pressure and current, either separately or combined. He then proceeded to describe some "non-registering instruments" or current measurers only, premising that any current measurer may be converted into a recorder of quantity or a coulomb-meter by the integration of the time during which the current has flowed. Under this head, then, he placed Siemens's electro-dynamometer, Obach's tangent galvanometer, Cardew's low-resistance galvanometer, Ayrton and Perry's ammeter, and Sir William Thomson's current galvanometer; under the head "Pressure Measures," he classed and described Ayrton and Perry's voltmeter, Sir William Thomson's potential galvanometer, and Siemens's torsion galvanometer; then followed Ayrton and Perry's power meter, and Siemens's watt-meter, which were identified as "power or energy meters;" and, lastly, "Resistance Measurers," under which head Ayrton and Perry's ohmmeter appeared alone. Turning next to "Registering Instruments," Mr. Shoolbred thought that they might be divided into two classes, 1st, quantity, or coulomb-meters; and 2nd, energy, or work meters. The first of these classes again could be split up into A, those based on electrolytic action, and B, those which were mechanical in principle. Under Class 1 A, the following

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meters were described, viz.:—Edison's and Sprague's. Under Class 1 B, came Hopkinson's and Boys's. Finally, under Class 2, the author dealt with Boys's energy meter, Deprez's ditto, and Ayrton and Perry's erg-meter. Mr. Shoolbred concluded with the following words:—"It is probable that the supply of electricity in a town will be carried out at a certain defined standard pressure or electromotive force, which will be guaranteed to the consumer; and to assure the fulfilment of this condition special steps will be taken by the local or other authority. The consumer need, therefore, but concern himself, as far as the supply he receives and has to pay for, with the quantity of electricity which he has made use of. In fact, the meter he makes use of to record it may be a coulomb-meter. The work, or energy-meters will not be needed for general application, but only in special cases. The brief review just made of the subject of the measurement of electricity, as well as of some of the instruments employed in it, will, it is hoped, tend to show that measurement of a very precise nature can be made; more so, indeed, than perhaps in any branch of physical science. Also, that a large number of very effective instruments already exist."

Sixpenny Telegrams.—In the House of Commons on Thursday last, Dr. Cameron moved "That the time has arrived when the minimum charge for inland postal telegrams should be reduced to 6d." The hon. member supported his motion in an able speech, in which he brought forward a number of arguments in its favour. Several other hon. members joined in the debate. We are compelled, however, to omit all mention of their speeches, owing to the pressure on our space, and must, perforce, confine ourselves to the following extracts from the answer made by Mr. Fawcett, the Post-Master-General. He said, that "It appeared to him that the proposed reduction could be reduced in three different ways. As his hon. friend had suggested, they might have a charge of one halfpenny a word with a minimum charge of 6d., addresses being charged for; or, secondly, as advocated by his noble friend who preceded him, they might continue the free addresses, having a minimum charge of 6d. for six words, and one halfpenny for each additional word. The third way was a simple one—to retain the free addresses and charge 6d. for the first six words, 9d. for twelve, and 1s. for twenty words. Unfortunately, each of those plans varied in costliness directly as their convenience. The first plan was the least costly and the least convenient. The second was considerably more costly than the first, and the third still more costly than the second. Therefore, in considering the matter, the Government would have to consider, when the change was adopted, what amount of revenue they were prepared to sacrifice for the convenience of the public. He wished to state as briefly as possible what were the estimates of the loss involved in the proposed reduction. He had had the assistance of two of the ablest officials of the Post Office in making the estimate, and he would give them the figures of the official who put the loss at the maximum. In the first year, if a rate of one halfpenny a word were adopted and addresses charged for, the loss would be, as stated by his hon. friend, £179,000. He estimated that the loss would rapidly diminish, and that in four years time the telegraph would yield as large a sum as at present. The second plan, which was favoured by his noble predecessor in office, would be much more costly. The estimate was in that case, that the loss, instead of being £179,000 in the first year, would be £150,000 more than that, or in other words, that the loss would be £320,000, which would bring the revenue down to little more than £40,000. But in stating the advantages which belonged to free addresses, and the disadvantages which would attach to charging for each word of the address, it ought not to be forgotten that the present plan was extremely wasteful. He thought there was some force in what was urged by his hon. friend, the member for Glasgow—that considering they had at the present time 5,900 telegraph offices, it showed but a small amount of business when they had only 80,000 telegrams a day, or an average of about 14 for each office. He thought, as he had stated on a previous occasion, that the shilling telegram was a prohibitory charge to a considerable section of the lower middle class." Criticising Dr. Cameron's figures as to the revenue derived by the Post Office from the telegraphs, Mr. Fawcett said that "He would give the House the revenue of the Telegraph Department, calculated on commercial principles, during the last three years, and they would at once see that that law of continuous increase (put forward by Dr. Cameron) did not, unfortunately, apply to that service. In 1880-1 the commercial profit from the service was £440,000; in 1881-2, it sank to £353,000; and during the present year, with an increased capital of £200,000, on which interest ought to be allowed, the commercial revenue was £363,000, or, reckoning £6,000 for interest, only about £4,000 instead of £50,000 better than the year previous. No doubt the falling off was due to the circumstance at which his hon. friend had hinted. The salaries of the telegraph *employés* had, he did not say by the pressure of the House, but certainly with the approval of the House, been increased. He did not regret that increase. He thought the extra pay they received was due to them, and if it had not been so he could only say that no number of memorials would have induced him to recommend the Treasury to make such a sacrifice of revenue. What, then, was the financial position of the telegraph service? Their capital might be taken at ten and a-half millions; £353,000, the profit on the year 1881-2, would represent an interest of $3\frac{1}{4}$ per cent.; and the profit on the present year represented about $3\frac{1}{3}$ per cent. Therefore, from that point of view, the telegraph service might be considered at present to be just a paying concern, yielding the current rate of interest upon the capital expended. But there was another consideration on which he should not be very frank if he did not say a few words. The capital of ten and a half millions represented the sum that was paid by the State for the telegraphs. But, owing to the blunder committed by the Government and sanctioned by Parliament—for both the Government and Parliament were alike responsible in the matter—they were saddled with what might be regarded as a useless capital expenditure of three and a half millions, because he was told on the highest authority, by which great pains had been taken to investigate the subject, that if instead of the ten and a half millions that were paid for the telegraphs, £7,000,000 had been paid, that would have been a large, if not an extravagant sum." Mr. Fawcett concluded by saying that "whether the day came soon or came late, the very moment they received an instruction from those in superior authority, either from the Government or from his right hon. friend the Chancellor of the Exchequer, that the revenue was open to lose for one year £170,000, and for four years an aggregate sum of £450,000, that news would be welcomed at the Post Office, because all that they considered they had to do was to make what revenue they were ordered to make for the Government, at the same time giving the utmost possible facilities to the general public, either postal or telegraphic." The result of the debate was that the motion was carried by 68 votes to 50.

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THE (ELECTRIC) CONDUCTIVE AND INDUCTIVE CIRCUITS GEOMETRICALLY ILLUSTRATED.

BY F. C. WEBB, M.I.C.E.

(CONCLUDED FROM PAGE 393.)

The Wheatstone bridge is shown in Fig. 57. A E is the potential at the battery pole attached to bridge, the other pole being to earth. A B and A C are the ratio branches of the bridge, and the galvanometer G is connected between C and B. When balance is obtained the potentials at C (C D) and B (B F) are equal. Therefore, if B L be the resistance plugged to obtain balance, then C M will be the resistance that is being measured. Fig. 58 shows a bridge "out of balance." The resistance B L has been made too great for the unknown resistance C M. The potential at B becomes greater than that at C, and there is a current, therefore, from B to C, through the galvanometer, shown by the inclination of the line D F. But the potential B F is still less than the potential would be at B if, with B L in circuit, that resistance was properly balanced by a resistance between C and earth. This

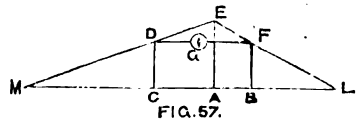

FIG. 57.

gives a steeper inclination to the potential lines in A B (E F), showing a greater current in that branch and a less steep potential line (F L) in B L, showing a decrease of current in that branch. In the same way C D is less than before; consequently, D E is steeper than before, and M D is steeper still, for it is the resultant of the two currents represented by the inclinations of D E in C A, and *illustrated* by the inclination of the line D F in the galvanometer. This latter line does not actually represent by its inclination the current in the galvanometer, because the length C B does not represent the resistance of the galvanometer. Nor do the proportionate inclinations of any of the lines show the correct proportion of current, as they are not worked out, but only drawn, of *greater* or *less* inclination, according to the evidence of the case.

Inductive Circuits.—The term "inductive circuit" is one I introduced some twenty years ago, when showing the applicability of Ohm's law to problems of electrostatics. It will be seen that, wherever accumulation of electricity occurs on the surface of a conductor attached to one pole of a source of

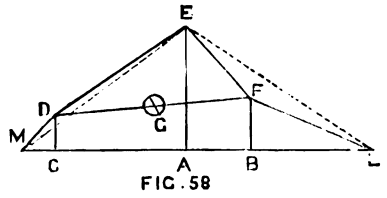

FIG. 58

electricity, the quantity that can be accumulated is dependent on the geometrical dimensions and the specific capacity for induction of the dielectric separating that surface from the surface to which the other pole of the source is attached. Thus, to take the simplest form, suppose a battery having one pole attached to a hollow sphere, and the other pole attached to a sphere placed concentrically within the hollow one. Then all the inductive effect would go on between the outer surface of the inner sphere and the inner surface of the outer sphere, and the quantity that would be accumulated would depend on the dimensions of the spheres and the nature of the dielectric separating them. We have an inductive circuit having only one resistance, namely, the shell of dielectric separating the two spheres. If we have two or more successive resistances in the circuit, then the quantity accumulated on any one of the surfaces depends on the *total* resistance of the inductive circuit.

Thus, if each pole of a source was connected to a sphere, each contained in a hollow shell, and the two shells are joined by a conductor, the quantity accumulated on any one surface will be inversely proportional to the *sum* of the two resistances—or, generally stated:* "*The quantity of electricity on any one surface of an inductive circuit composed of successive resistances will be, with a given source, inversely as the sum of all the successive inductive resistances in the circuit; and the quantity on each surface is the same throughout the whole circuit, but opposite in name on any two successive surfaces.*"

Thus, if a given battery has one pole attached to one plate of a condenser and the other pole to the other plate, the quantity accumulated will depend solely on the dimensions and nature of the dielectric of that condenser, and if we placed a similar condenser, but of half the inductive resistance (*i.e.*, twice the capacity), the second one would accumulate twice the quantity. For we have only one resistance in the circuit, and when we halve that we double the quantity. But if now we have a source, S (Fig. 59), one pole of which, N, is connected to a condenser plate, A, the other plate of which, B, is connected to a plate, C, of a second condenser, the other plate, D, of which is connected to the other pole, P, of the source, then, if we alter the condenser D C to twice its size, as by increasing the plates D' C', we shall no longer increase the quantity in this new condenser to double what was contained in the first one, for we have not halved the *total resistance* of the circuit.

In the same way, if we have two submarine cables of similar pattern and different lengths with distant ends insulated attached to the poles of a source, then the quantities in each would be *equal*, and opposite in name, but this quantity would depend on the total resistance of the inductive circuit. The quantity in either could never equal the quantity that

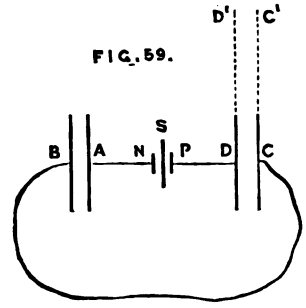

FIG. 59.

would be accumulated in one if that was the only resistance in the circuit. When the two are equal in resistance the quantity will be exactly half in each of what the charge would be if the other was cut out of circuit. And if one remains constant, and the other be constantly increased in length the quantity in the smallest will constantly increase towards (but can never equal) the charge that it would receive if the other did not exist.

This can be illustrated geometrically; but for this we have here to represent the *capacities* of the cables instead of their *inductive resistances*, and as the pattern of the cables, *i.e.*, the internal and external diameters of the gutta percha envelopes are supposed constant, the absolute lengths will be proportional to and represent their capacities.

The problem is as follows:—To find the potential and charges in two wires B C and A F of different lengths (but similar in section) when attached at B and A to the two poles of a battery B A (the electromotive force of which = A O), whilst their distant ends F and C are insulated. Let B C and A D represent the capacities of the two conductors under equal conditions as regards inductive resistance to a common conductor *x* (for instance the sea, supposing the wires were submarine wires). Let A B represent the battery, and A O the electromotive force or potential when one pole, A, is insulated, and the other, B, to earth. Then if a wire, A D, similar to B C, existed at A D, the potential in B C and A D would be equal, and equal to half A O, and the charges A D E N and B G H C would be equal, but of opposite sign. Suppose A D were now prolonged to A F. Then must the potential in A F be less than in A D, and the potential in B C must rise so that the products of the capacity A F

* "Electrical Accumulation and Conduction" (1862), p. 87.

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and its potential A K shall equal the product of the capacity B C and its potential B M; or, in other words, the value of the two charges must still be equal. But, further, the sum of the two potentials, under the new conditions, must remain the same, for otherwise it would indicate a change in the electromotive force. Join E G.

Join F E and draw D J parallel to F E. Join J G, and through L, where J G cuts A B, draw K M parallel to E G, cutting A E at K and B G, produced at M. Draw M P parallel to and equal to B C, join H P. Draw K Q parallel to and equal to F A, and join F Q. Then will K A be the potential in A F, and A K Q F the charge in F A, and B M will be the potential in B C and B M P C the charge in B C.

For since D J is parallel to F E, the △'s D A J and F A E are similar, and the angle D A E common to both,

therefore A J : A E :: A D : A F,

2ndly. A L : L B :: A J : B G, but B G = A E (const.)

therefore A L : L B :: A J : A E,

A L : L B :: A D : A F, { "Euclid," Book, V., Prop. 11.

but A D = B C,

therefore A L : L B :: B C : A F.

Again, the △'s A L K and B L M are similar, as ∠ K L A = ∠ B L M, and ∠ L A K = ∠ B M,

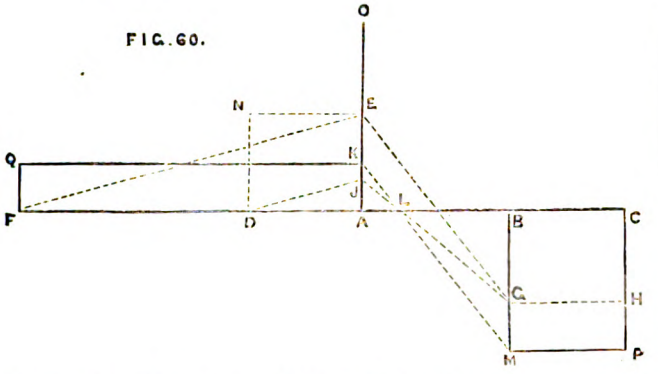
therefore K A : B M :: A L : L B,

but A L : L B :: B C : A F,

therefore K A : B M :: B C : A F, { "Euclid," Book V., Prop. 11.

or K A × A F = B C × B M, or the charges B M P C and A F Q K are equal.

FIG. 60.



Now, since K M is parallel to E G, and E K is parallel to G M, then E K M G is a parallelogram, and E K = G M, therefore A E − E K + B C + G M = E A + B C = the potential of A D and B C, but A E − E K + B G + B M = A K + B M = the potentials of A F and B C.

The sum of the potentials remains, therefore, unaltered, but if the potential at A was greater than A K, then, for the sum of the potentials to remain the same, the potential at B must be less than B M. The charge of A F would, therefore, be greater than A F Q K, and the charge of B C would be greater than B M P C. But it has been proved that A F Q K = B M P C; therefore, if potential A was greater than A K, the charges in A F and B C would be unequal, which, by the first principles of the case, it is asserted is impossible, since no generation of electricity of one name can take place without an equal quantity of the other being generated.

In the same way it may be proved that the charges would be unequal if the potential at A was less than K. Therefore, A K is the potential at A, and B M the potential at B, and the charge in A F is A F Q K, and the charge in B C is B C M P.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of March was 5,138, estimated to produce £4,500, against 4,300 messages, producing £4,123, in the corresponding month of last year. The traffic receipts for the month of December, estimated at £2,800, realised £3,068.

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XVIII.

Before taking the discharge test, for which 50 or 100 cells may be used, the capacity of the cable may be found, and this should be determined for the time being, since it may vary a little. If the ordinary discharge method of finding it be employed it is most convenient to connect the standard condenser in the place of the cable in the figure, and to shift the plug in the battery commutator (here not shown) to the place for 10 cells; then to take the condenser discharge, and after substituting the cable take its discharge also. The connections then are ready for the insulation test, the only change necessary being the shifting of the plug in the battery commutator to the 50 or 100 cells place. A shunt is required in every instance to regulate the deflections. That for the condenser will most probably be on record, as the same condenser will be in use for all purposes. At any rate the capacity test will have been taken with the same arrangements, and our remarks in a previous number on capacity will suffice for any reference to the subject. The cable shunt, or that to be used for producing a readable deflection when the discharge is at full potential, will be smaller, or otherwise, according to the length of the section, so that, after taking the condenser reading, the shunt plug will be shifted to introduce a suitable branch resistance as shunt. An ordinary resistance box is the best form to employ

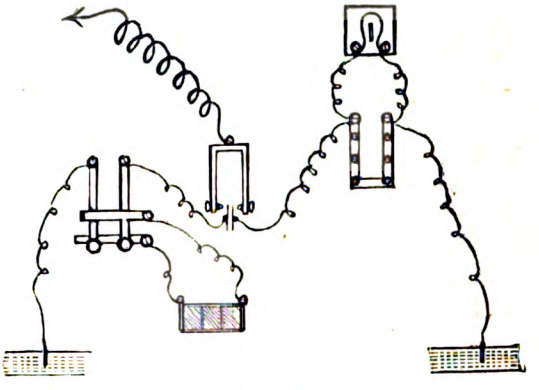


FIG. 39.—Insulation Resistance (Discharge Test).

even if there be a proportional arrangement for the galvanometer, as formerly explained. In a long section of cable we should probably have to use one unit only for shunt, perhaps less. The connections then being arranged for the cable test, the battery key will be clamped down to produce a negative charge. It is seen that no current can flow until the Lambert key, to which the cable is joined, comes into play, and by this arrangement the battery is always prepared for action. It will be noticed that we have not in this figure (Fig. 39) introduced a commutator for the galvanometer, though it may very probably be used, but it is not essential. In order to have as large a deflection as possible, it may be well to alter the zero on the galvanometer scale, and to turn the directing magnet till the spot is brought back to the end, giving it a range of the whole length. As 0 is in the centre this removal will bring the spot, say, to 400 at the left hand corner, and it must be remembered in valuing the deflections that the addition of these 400 divisions is to be made to all those that are passed over above the zero at the centre. Thus, if the deflection was 200 to the right of zero, the true value would be 600, and so on. It is not, however, always necessary to give so large a range; it must be determined according to circumstances. To continue the test, the battery key being down, the Lambert key is depressed on the side connecting with it, and the cable is thereby charged. This key is sometimes kept down for ten seconds, sometimes five, and then released, and the other side of the same key instantly touched down, when the cable is discharged through the galvanometer and a deflection produced, which is recorded. The operator

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must be very careful in doing this to release the charging contact of the Lambert key before touching the other contact, though no appreciable interval must be allowed. One finger for each contact is most convenient for this purpose; the charging contact is set free by one and the discharge depressed by the other. The reason is that the cable may have no time to leak, and that the whole of the charge may be immediately extracted. For want of attention to this caution a beginner will very likely touch down the discharge side a trifle too quickly; in which case he will get no deflection, and will be puzzled, not being conscious of the act. We have now got the full potential, and have to determine the value after a certain period of leakage. To do this under the most favourable conditions the cable should be entirely free of charge; indeed, there ought not to be any left in it, or our deflection would have represented an imperfect discharge. But, to make the several discharges fairly comparable, the cable should be as free as possible on each occasion of charging. The discharge side, therefore, of the Lambert key should be tapped down a few times before recharging. The student observes that this puts the cable to earth through the galvanometer and battery key. We may now put down the charging contact of the Lambert key for a few seconds and release it, waiting one minute during which the cable leaks (discharges slowly through the insulating sheath); at the end of this time the other contact is touched down and the deflection noted. The operations are repeated at the required

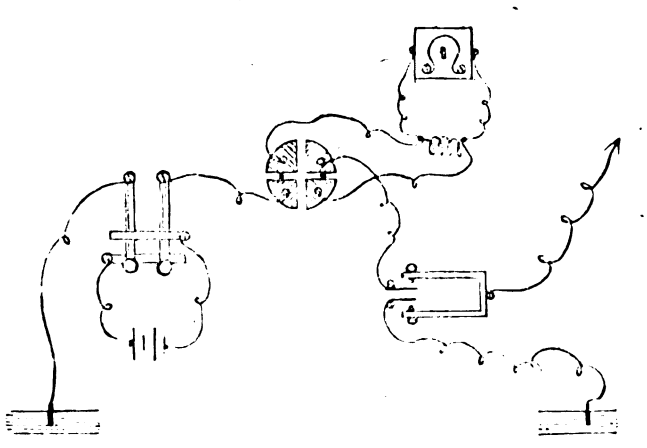

Fig. 40.—Insulation Resistance (Charge Test).

intervals; sometimes no other observations are needed. Sometimes the cable is discharged after 2, 3, 5, and 10 minutes' leakage, but the course is the same all through. The result has given us all the conditions necessary to calculate the insulation resistance by the rule above mentioned. We have the time of leakage in each observation—this is 1, 2, 3, &c., minutes, as it may be, also the capacity in microfarads by comparison of the full discharge with that of the condenser, and we have the different deflections representing full potential, and that at various intervals. We have only to work out the formula.

We are now to vary the test by the "charge" method. There is very little difference between the two tests, but the connections are slightly varied. In Fig. 40 a plan is given which might, indeed, have been used for the discharge test in place of that in Fig. 39. This way of arranging the matter would be most convenient if we wished to make it a discharge test without any alteration. The difference between the two figures is that in Fig. 39 we charge the cable separately and discharge through the galvanometer, and in Fig. 40 we both charge and discharge through it. Both tests can be taken, however, with either plan. The arrangement in No. VII. for taking capacity would also answer our purpose. It is to be observed that, for the operation now to be performed, we require a different shunt to that used just before; that is, if the same cable is being tested. This will readily appear from the consideration that the deflections in the first case are caused by a greater amount of charge than in the second. When a cable is charged for 10 or 15 seconds, it will only discharge or leak slowly through its dielectric; thus, the amount left in it after one minute is greater than the leakage, and consequently than the amount necessary to replace it when recharged. The change in shunt power must depend on several considerations, as the length of the cable, its qualities, battery power used, &c. In a case of actual practice in testing a submerged cable a shunt of one unit was used for the discharge and one of 10 units for the charge test, the deflections being about equal in both cases. Following Fig. 40, we commence, as before, by clamping down the battery key. No charge can flow as long as the Lambert key is not down; on depressing this, the cable is charged and the deflection noted. The full potential is the same whether observed by the charge or the discharge, and if we had the commutator plugs properly arranged we might charge the cable from the battery key and discharge through the galvanometer, as in the discharge test. We might then charge again, and, leaving the cable to leak for one minute, place the commutator plug in the reverse position, and after the minute by touching down the other Lambert key contact replace the amount of charge that had escaped. The deflection on the galvanometer represents this compensating quantity. The advantage of doing it in this way is that we can give the 10 seconds for the first charge, as before mentioned. The resistance is calculated so as to give the value for discharges, as previously suggested.

The earth connection to the Lambert key in Fig. 40 is for putting the cable direct to earth if needed.

In the next number we have to give other examples of this kind of test with the electrometer as well as galvanometer.

BLACKBURN'S PORTABLE TESTING BRIDGE.

When submarine telegraphy became practical, testing became a science, and the instruments used for testing purposes developed with great rapidity into scientific apparatus of very great accuracy and delicacy. Electric light work requires special apparatus, not, perhaps, of so delicate a character, because the electric currents are far more powerful than those used in telegraphy. A good deal of work has been done by "rule of thumb," the only definite object being to be on the safe side, but this must gradually give way to better and more scientific methods. The electrical engineer will have to know his instruments and familiarise himself with their use in much the same way as the civil engineer familiarises himself with the use of the chain and theodolite. Ohm's law must be the watchword of one just as square measure is of the other. Practical electrical engineers have already found the want of simple portable apparatus, and endeavours are being made to supply the want. The instrument we herewith illustrate is an example of this fact. It is a combination instrument specially designed for a certain class of work. Mr. A. B. Blackburn has designed, tested, altered, and tested, till he has produced a most compact, portable, and useful instrument. We have said this is a combination instrument, and we think justly so, in that it contains a Wheatstone bridge, galvanometer, and battery, complete, and connected up for instant use. It is, box and all, not more than about 7in. by 5in. by 1·5 in., so that it goes easily into a handbag, or even into the pocket. Its measurements are said to be fairly accurate between the limits ·005 and 2,000 ohms. Fig. 1 shows the arrangement, and is almost the exact size of the instrument, while Fig. 2 shows the connections. It will be seen from Fig. 2 that the resistance coils are placed around the circumference of a circle. Eleven coils are so arranged in series beneath the turntable. The latter carries two contact pieces, which embrace two coils. A platinum wire having double the resistance of one coil is stretched round the ege of the turntable, and joins the two

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contacts. This wire is used for final adjustment, and is capable of division at any point by an index arm, this index arm carrying the battery current. In Fig. 1 the index arm is connected to two movable plugs, shown in Fig. 1 at X, and in block marked 10. One of the plugs is placed at contact X, the other in the block numbered with the number

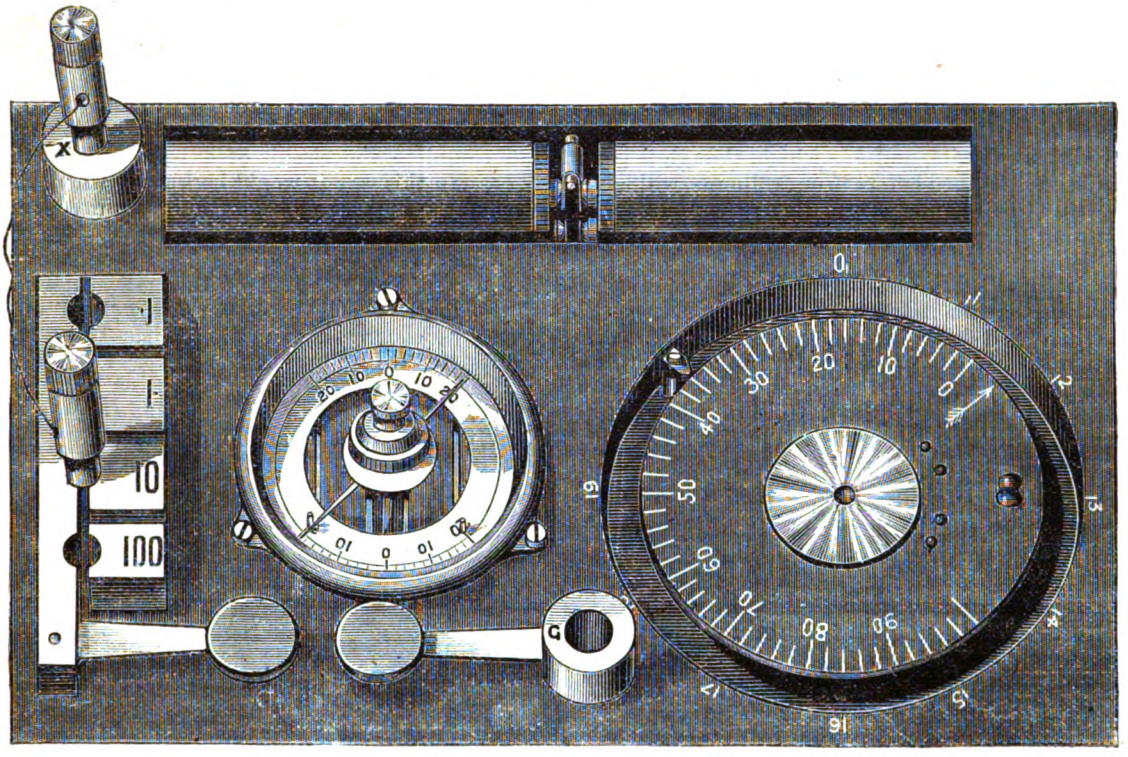

Fig. 1.—Blackburn's Testing Apparatus.

is shown at division 36 of the platinum resistance. Other coils forming another arm of the bridge are arranged in a line as shown, and have respectively the resistances ·1, 1, 10 and 100 ohms. The galvanometer is astatic, the needle being most nearly approaching the supposed resistance of the wire, carbon, &c., whose resistance is to be measured. When the instrument is used as a detector the terminal plugs are placed, one in a numbered block, and the other at G. The instru-

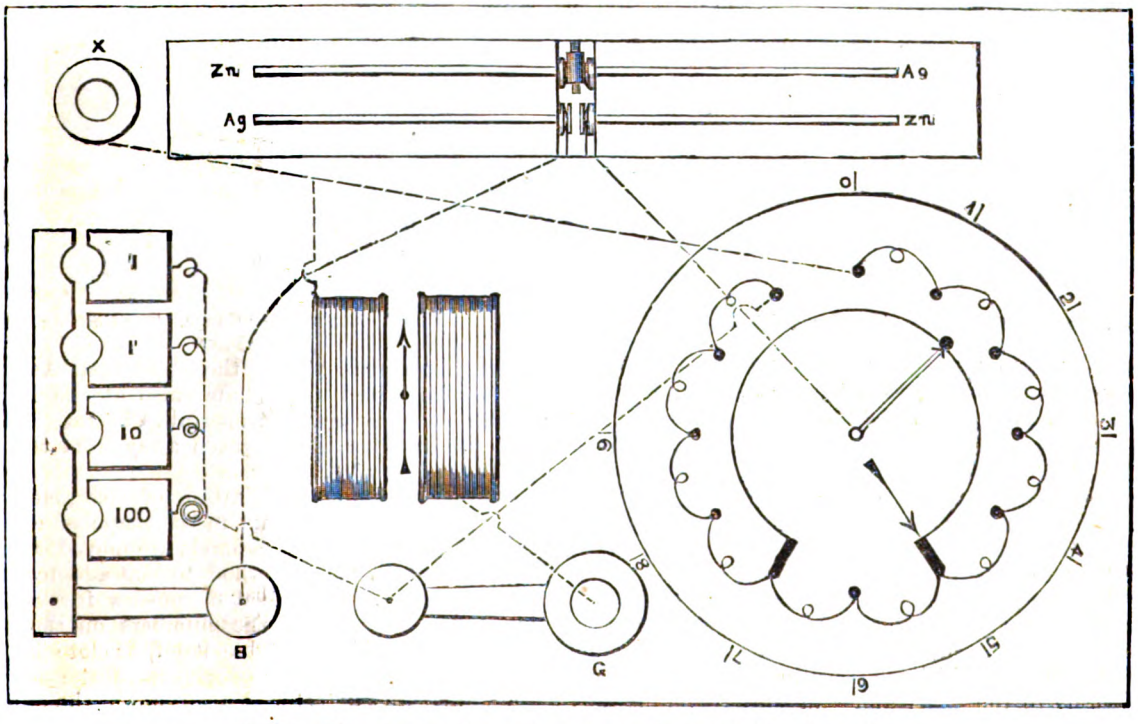

Fig. 2.—Plan showing Connections of Blackburn's Testing Apparatus.

suspended by a silk fibre. The battery consists of two chloride of silver cells joined up in series. When the instrument is used to measure resistance, the unknown resistance ment is constructed by Messrs. Clark, Muirhead and Co., who with each one issue a small pamphlet explanatory of how to use the apparatus.

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THE ELECTRICAL EXHIBITIONS.

(CONTINUED FROM PAGE 392).

One of the best stands at the Crystal Palace Exhibition is, without doubt, that of Mr. JULIUS SAX, of Great Russell-street, W.C. His collection of apparatus is of a rather miscellaneous order, and ranges from water gauges to electric bells. We may begin by describing the former as the most important of all his exhibits, and one which, though it is not new, and has been described before in our columns, will admit of re-description at our hands, especially as the number and volume containing the previous description have long been out of print.

The gauge is intended primarily for use at waterworks, where the pumping station is often some distance from the reservoir, and its object is to indicate to the engineer in the pumping station the exact depth of water in the reservoir at all hours. The gauge can, however, be adapted to the lesser requirements of house cisterns. It consists of two parts, a transmitter, and receiver. The transmitter, a front view of which is shown in Fig. 1, is placed above the water the depth of which is required to be measured. To one end of the chain, which can be seen depending from the interior of the apparatus, a float is attached, and to the other a counter-weight. The chain passes over the wheel P, shown in the plan view (Fig. 2), which is geared into the pinion on spindle A. This pinion is calculated to turn round once for each inch that the float rises or falls. It is connected to the index hand by two sets of gearing, one of which is set in motion by the rising of the float, and the other by its fall, the index hand being moved forwards or backwards respectively. On the pinion A are also carried two insulated weights W, one only of which is shown in the figure. These are fitted loosely to the axle, and can only travel one way each by means of a small trigger. Supposing that the float is falling, the weight W will be carried round, and cause the contact piece C to make contact with the springs S, which will have the effect of sending a positive current over the line to the receiver, the index hand of which will indicate one inch of fall; the same action will take place for each succeeding inch through which the water may recede. Should there be a rise in the water, the other insulated weight, not shown in the illustration, will be carried round in the opposite direction to that above mentioned, and cause the contact piece Z to make contact with springs S^1, sending a negative current over the line to the receiver, which will indicate one inch of rise, and so on. Little movable contact pieces will be observed on the face of the transmitter *a* and *b*, Fig. 1. These can be set to any depth that may be required, and directly the hand makes contact with them it will complete the circuit of a bell, say in the engineer's office. In this way it would be known when the water had reached the highest or lowest limits required, or safe. A front view of the receiver is shown in Fig. 3. On starting these instruments the hand of the receiver should, of course, be set at the same figure as that of the transmitter. The working of the receiver will be better understood on reference to Fig. 4, which gives a plan view of it. The currents from the transmitter are led to the two pairs of electro-magnets shown, and, according as they are positive or negative currents, so is one or other of the wheels carrying the hand moved to the right or left by the action of the electro-magnets. This water gauge is in use at the Prudential Assurance Company's offices in Holborn, and also at the Duke of Westminster's country seat, Eaton Hall, Chester. At the former place the receiver is 150 yards away from the transmitter, and at the latter 900 yards.

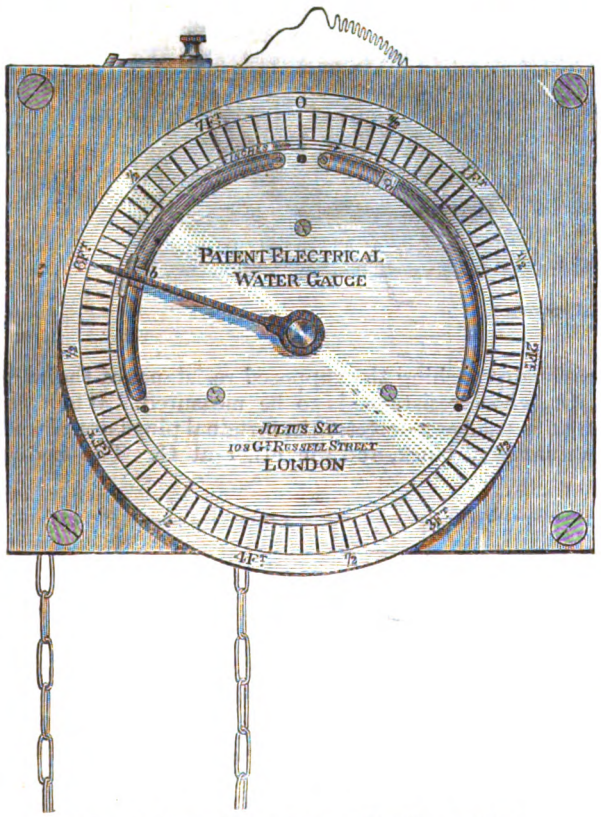

FIG. 1.—Sax's Water Gauge. The Transmitter.

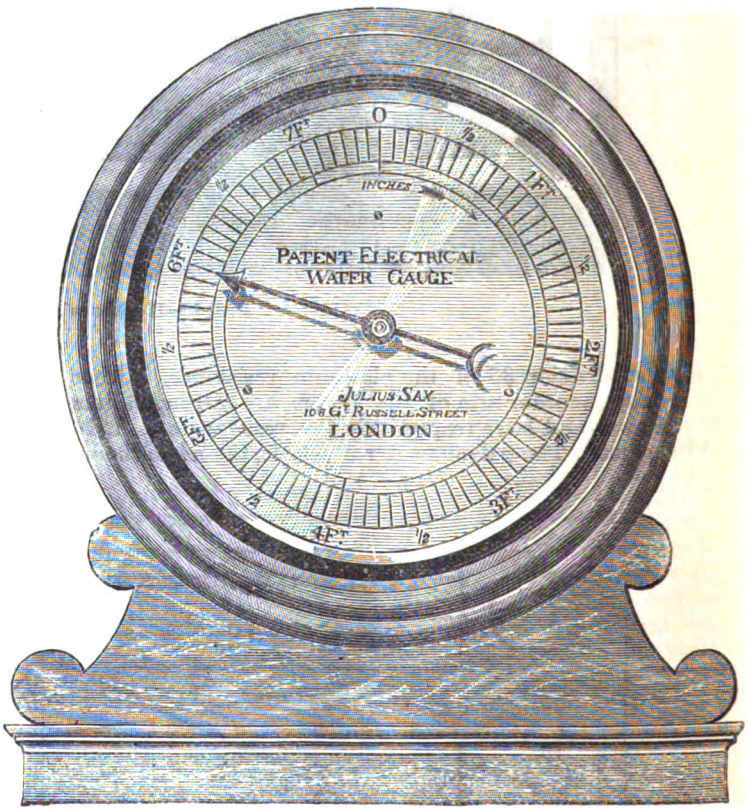

FIG. 3.—Sax's Water Gauge. The Receiver.

Another ingenious application of electricity to everyday wants is shown by Mr. Sax, in the shape of electric billiard markers. In this case the hands are moved round the dials by a somewhat similar method to that adopted in the water-gauge receiver. The contact pushes for completing the circuit and registering the numbers on the dials can be placed on the billiard table itself, or close by, in any convenient position.

A watchman's detector is also shown, the object of which is to obtain a register of the time at which any particular watchman has visited a certain part of the premises under his charge. It consists of a clock to the works of which is attached a drum, so that both revolve synchronously. Round the drum is wrapped a piece of paper divided into eight parts to represent days, and again into twenty-four to represent hours. Inkers bear against the paper, and are connected

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with electro-magnets, which in turn are in circuit with contact pushes. These latter are distributed throughout the premises at the points required. Supposing the clock to be set going at 12 p.m. on Monday, the drum will begin to register from that time, and on the watchman pressing one of the contact pushes—say at 1 a.m.—the particular inker connected with that push will make an impression on the paper of the drum, and record the fact that he visited that part of the premises at that hour on that day.

In addition to the above described apparatus, a large number of electric bells are shown, as well as burglar alarms. Mr. Sax exhibits the system of bells devised by him for the Metropolitan Fire Brigade, and already fitted in several stations. It includes a switch-board in the superintendent's

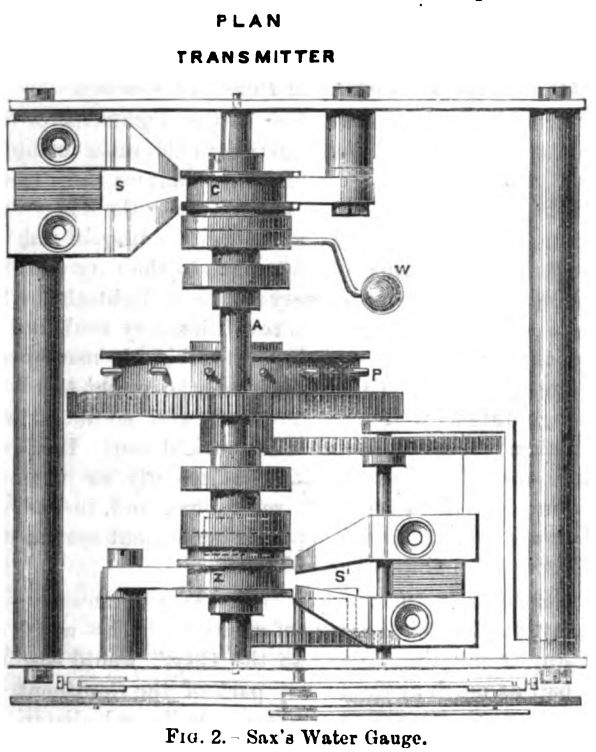


Fig. 2.—Sax's Water Gauge.

room, which enables him to cut off so many men's bells, and thus call up only those who are wanted, and also a pneumatic spring contact arrangement, the action of which is slow enough to keep the bell ringing for several seconds when once it has been set in action. Of the burglar alarms we have not much space to speak, but we may say that some of them are very ingenious. In one, which is designed for use with safes, the burglars may give the alarm in two ways, so

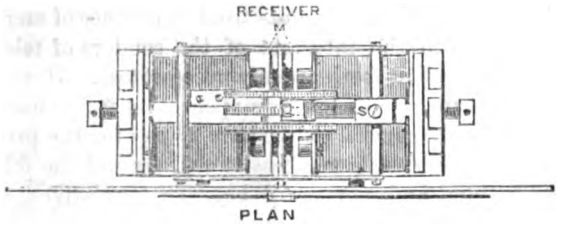
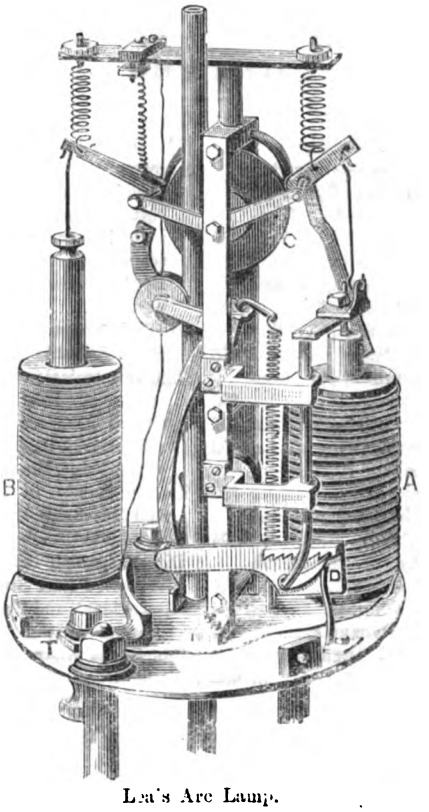


Fig. 4.—Sax's Water Gauge.

that if one alarm should be disregarded or fail to act there would be another left. Mr. Sax's exhibit, as we have said, is one of the best of its kind in the Palace, and we must also give him the credit of having been ready and his apparatus in place very much earlier than his neighbours.

The Lea Arc Lamp.

This lamp is exhibited by the Werdermann Company. The machinery occupies the position taken up by the Brush Company last year. The lamps are arranged in two circuits, each circuit having five lamps in series. The resistance of each lamp with its arc is about 2 ohms, thus giving a resistance to each circuit of about 10 ohms. The current used is 20 amperes. The E.M.F. of the machine must, therefore, be $20 \times 10 = 200$ volts. The current is supplied by two E Gramme machines, one A Gramme being used as an exciter. The action of the different parts of the lamp will be best understood by tracing the current, which enters at the positive terminal, then passes by t e uninsulated parts of the lamp to the rollers guiding the upper carbon holder and by the holder to the upper carbon, then across the arc to lower carbon, and from hence by a side rod and the thick coil A to negative terminal T. The thick coil A is wound with five layers of wire, and has a resistance of about $\frac{1}{17}$ ohm. The current through solenoid A causes the core to be drawn down; connected to this is a gripping lever, which brakes the disc C, turning it round, raising the carbon-holder and carbon, and thus striking the arc. When the core is pulled quite down, an arm fastened to the gripping lever comes into contact with a pin, thus releasing the lever, and unbraking the disc C. The action of the core of A also releases the pawl and rachet at D, allowing the spring shown close to D to act upon the



Lea's Arc Lamp.

jockey wheels, which clutch and guide the carbon-holder. The feed arrangement is as follows:—The solenoid B is wound with two sections of wire, each section having about 250 ohms resistance, one section only being in the first instance in circuit. A proportionate part of the current passes through the coil, becoming larger and larger as the arc increases in length, and hence in resistance. The action of the current draws in the core of B, to which a brake is fixed, acting on disc C. The brake acting on C slightly rotates it, and this lowers the upper carbon. Should the feed be too great the second resistance is automatically brought into circuit, thus diminishing the current through B, the pull in the core, and the action of the brake. A short circuit arrangement is made between the + and − terminals to act as a cut out. The cut out is actuated by the spring at D, which, should the carbon, for example, become too short and danger arise of burning the holders, acts as follows: The upper holder is so made that in the case cited it would fall below the highest pulley, and the spring which causes this pulley to clutch the holder pulls the pulley over and with it a long bent arm, which comes into contact with a continuation of terminal T. We have watched the feed of this lamp by the kindness of Mr. Mackie, who has charge of the exhibit at the Crystal Palace, and found it to be very constant. The inventor has, by a neat arrangement of hollow rods, made the lamp so that the lower and upper parts take asunder.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

D. DURNFORD.—*Professor Thompson's lectures on dynamos have been republished by the Society of Arts in pamphlet form. The society's address is John-street, Adelphi, W.C. We do not intend to republish them ourselves.*

J. GOULD (TAUNTON).—*The date of the discovery of the thermo-battery by Seebeck should be* 1822, *and not* 1882, *as stated on p.* 447 *of our issue for the* 24*th inst.*

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SIXPENNY TELEGRAMS.

It could hardly be by accident that the Government suffered a defeat the other evening on the question of sixpenny telegrams. The new Chancellor of the Exchequer either wished to have his hands forced, or else some influence more powerful than his own decided that they should be forced. Whichever of these two views we adopt the result is the same. The House of Commons, unless it deliberately reverses its own decision, which it rarely does, is bound to press for a reduction in the rates of telegrams within a reasonable space of time. Not so much from what he said—so the newspapers tell us—as from his manner of saying it, the Postmaster-General let it be seen that he was an advocate of sixpenny telegrams; and not so much from his manner as from his matter, perhaps, Mr. Childers betrayed that he was not. A Chancellor of the Exchequer loses nothing by being slow to part with public revenue; a Postmaster-General gains a good deal by being zealous in administrative reforms. After a friendly duel of this kind, both parties alike are decked with laurels, and the lookers-on retire much edified.

The cheers from below the gangways on both sides of the House which greeted the numbers of the division were, however, it seems to us, more exuberant than the circumstances warranted. A division, it is true, is measured quite as much by the members who abstain from voting as by the members who vote. This, as a general rule, is a legitimate way of looking at the figures; but, in the present instance, if there were but comparatively few votes recorded against Mr. Cameron's proposition there were ridiculously few in favour of it. The absentees from the Opposition lobby are quite intelligible; but that the supporters of this great innovation could only muster sixty-eight followers is a phenomena requiring explanation, and is quite inexplicable on the theory that the country is eager for the proposed change. Nobody really believes that the country is discontented with the existing rates; what is believed and known is that the newspaper interests are working to get reduced rates for their own benefit, and that there is a government in power anxious to conciliate newspaper interests. The true motive did not appear in this debate; but true motives seldom appear in debates—except occasionally in *Punch's* "essence."

Some additional force was lent to the argument for a sixpenny tariff by the recent reduction in the rates to the Continent. Its advocates were able to say that "a short message could be sent at the word rate, including the addresses, to Paris or Brussels, for 10d., while the sending of the same message from the House of Commons to the City would cost a shilling." This was a discovery such as delighteth the heart of the doctrinaire. Anomalies revolt his very soul, and he is happy only when he is squaring everything to mathematical ratio and precision. To be consistent, he ought to advocate a mileage rate as well as a word rate, and no doubt he will do so when the word-rate vein is worked out. Half-penny postage was referred to, perhaps indiscreetly, as part of the programme of the Post Office reformers; and, indeed, some of their arguments point to a purely benevolent system which shall serve the public all round gratis.

It is nothing to such people that the very message—that is to say, an English message of average length—which costs a shilling from "this House to the City," would cost more than half as much again to any part of the Continent; nor do they note the fact that, bulk for bulk and distance for distance, our inland system is as cheap as that of any other country in the world—cheaper when the difference in the value of money is taken into account. We do not expect that the man who rides a hobby will see the foolish figure he cuts, nor that those other and cleverer people who use the hobby-rider for their own purposes will tell him where he is riding to. But we have a right to demand a little more candour and sobriety on the part of our public officials. Some of the arguments used in defence of sacrificing public revenue in the interests of the senders of telegrams ought to have called forth an emphatic protest. If we are to have a minimum rate so low as sixpence, let it be clearly understood that the general public have to pay for the privilege. The general public, it is needless to say, are not the telegram sending public, and never will be. Their relatives are not always dying, and they are not prohibited sending pathetic messages because of the shilling tariff. To assert the contrary is the merest claptrap. Roughly speaking, the senders of telegrams are a class by themselves. They are a very useful class, taken as a whole, though even this can only be asserted with reservation. It may be a national advantage to subsidise this class out of the national revenue, for a subsidy it is, and nothing less; but we have seen no attempt at proving the national advantage. On the contrary, the audacious assertion is made that the charge for telegraphic communication is itself a tax and a burden upon the people. Such assertions ought not to go unchallenged, for they may prove inconvenient some day; yet the Postmaster-General himself was betrayed into language which is

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capable of this interpretation—an interpretation which, pushed to its logical conclusion, would tax all non-users and non-consumers in order that a less numerous body of people may use and consume at reduced cost.

We repeat that it may be possible to prove the expediency of reducing the postal telegraph revenue and supplying the deficiency by national taxation, but as nobody condescends to argue the question on this ground we may fairly assume that the task would be a difficult one. It is even much easier to frame a resolution than to explain how it is to be carried out. "The time has arrived when the minimum charge for inland postal telegrams should be reduced to sixpence," so the House of Commons has affirmed by a vote of 68 against 50; but when we come to ways and means opinions are at variance as to the shape the the reduction shall take. The late Postmaster-General is in favour of retaining free addresses; the present occupant of the post considers them wasteful, and suggests three ways of bringing about a reduction, not one of which in all probability would receive the undivided support of a tolerably full House. The plan which he described as simplest and least costly was to continue the wasteful addresses and charge 6d. for six words, 9d. for twelve words, and 1s. (as at present) for twenty words. We do not think this would please the doctrinaires, for they would fail to see the reduction involved in sending six words for sixpence when you can now send three times as many for twelvepence; and we are sure it would encourage cypher messages to an inconvenient extent. The better plan, as every one knows who has studied the question, would be to include the addresses, and fix the maximum number of words at something like half their present average. Business people have short addresses and want long text; poor people, for whom Mr. Fawcett appears to hold a brief, have long addresses but need only a short text. Both classes would be accommodated by this plan, and the revenue would suffer least by it. But while the present superstition survives as to the prescriptive right of the English people to free addresses, it is useless to argue or to advise—one thing alone being now certain, that the senders of Press messages, their backers and their tools, will sooner or later wrest a fresh concession from the Government at the expense of the public revenue.

CORRESPONDENCE.

REIS'S TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I be allowed to comment upon the letter of Philipp Reis, and upon the remarks about it which appear in your last issue?

So far as is known, this letter is the only piece of English composition ever attempted by Reis. Of the few existing letters from his hand it is believed that all, save this, are in German. It is not surprising, therefore, that there should be, as pointed out in your article, points of obscurity in a letter written in a language which its author was so unaccustomed to employ. One blunder is so remarkable, yet so obvious, that it is surprising that it should not have been observed by the writer of your article which appears on p. 469. The word *tones* Reis, by mistake, wrote *tunes*. The second paragraph of his letter he began thus:—"*Tunes* and sounds of any kind are only brought to our conception by the condensations and rarefactions of air," &c. He obviously meant to write "*Tones* and sounds of any kind," &c., as is proved by the context; for at the end of the same paragraph we find him saying: "The smaller or greater number of oscillations made in a second gives us . . . . the idea of a higher or lower *tune*." This would be nonsense if *tune* were not evidently a slip for *tone*. Corrected to its obvious sense, the sentence is almost a *verbatim* paraphrase of a paragraph of his original memoir "On Telephony," on p. 58 of the *Journal of the Physical Society of Frankfurt-on-the-Main* for 1861.

This being so, the very slender verbal argument that Reis only intended to reproduce music—even if it were not refuted by the letter itself—falls to the ground. He clearly intended his instrument for "the reproduction of" *tones* "at any distance."

This blunder is paralleled by another which occurs in the original letter, but which, unlike the former, has been corrected in passing under the proof-reader's eye. In Reis's manuscript, where (p. 467, line 4) he is describing the arrangements of his contacts at the top of the telephone, he wrote "with the little *whole* (*a*) on the point (*a*)"; this, as now printed, runs "with the *hole a* on the point *a*." Here, again, the slip is obvious. But some one has in this case taken the liberty of correcting the blunder. There are several other mistakes of spelling (*e.g. wich* for *which*), which have been eliminated in the printing of the letter.

One other point cannot be passed by. It has been said that this letter of Reis shows that he only intended to transmit tunes and not other kinds of sounds by his telephone. The letter unquestionably shows the contrary. If Reis in his letter had said that *any sounds* could be reproduced, that would obviously have included speech; and surely he would have emphasised in some way such an important point. In one place, and one place only, did Reis emphasise by underscoring a word in his letter. What was the passage which Reis thus emphasised? *It is neither underscored, nor printed in italics in the reprint of the letter!* The passage which Reis emphasised was the following, near the end of his letter, and *in the original it stands as a paragraph, by itself*, though in the reprint it has been linked on to the preceding paragraph:—"*Any* sound will be reproduced, if strong enough to set the membrane in motion." Further comment is needless, save to inquire why the underscored word has not been emphasised in the reprint.

The suggestion that the words, "If a person sing," &c., which preface the paragraph in which Reis deals solely with what happens during singing, imply that it was not intended to transmit any other sound than singing, is so innocent a suggestion that to attempt to refute it would be cruel. It would be possible to set up an equally good argument that Reis did not intend to transmit music at all because in one place he calls the two persons who are respectively transmitting sounds and receiving them through the telephone "the correspondents."

Lastly, there is an argument (on p. 469, at the middle of the first column) concerning the "essential feature" of Reis's transmitter, which, as far as I can understand it, is to the following effect:—Reis, when describing in his letter the transmission of musical tones, spoke of the current being "opened" at every "full vibration;" therefore, he never meant to transmit anything but full vibrations, and meant the current to be opened not in proportion to the vibration, but always at all vibrations, whether full or not, just as completely as at every "full" vibration; therefore, his telephone could not speak "except by fortuitous accident." There is little to be said of an argument involving such extraordinary sequences, except that it is a very unusual and a very illogical one. Does it follow because a man says "I drink one whole bottle of wine at every full meal" that he never takes any meals but "full" ones, and that at every meal, whether full or not, he necessarily drinks one whole bottle of wine? Yet that is the logical parallel to the case. As it happens, though Reis had said it elsewhere, he did not in this his praiseworthy attempt to write an English letter, say what was to happen in the case of vibrations that were not of "full" amplitude. He never spoke of his contact arrangement as a mere "make-and-break" in the telegraphist's sense. He talked about his interrupting apparatus being for the purpose of opening and closing the circuit, which is a very different thing. And perhaps those who allege that an instrument which opens and closes the circuit cannot transmit

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speech had better reflect before they repeat the fallacy that in Edison's very first patent for "speaking telegraphs" (filed July 20, 1877, No. 203,014) the first claim was for the combination with tympans of "one or more circuit-closers," which in the second claim are called "circuit-breaking connections!" And yet we do still sometimes hear that an instrument which opens and closes the circuit—patented by Edison as a *speaking* telegraph—"could not speak except by fortuitous accident!" I am inclined to think that there are some writers upon telephone questions who cannot write with logical consistency except under the same condition.—Yours, &c., SILVANUS P. THOMPSON.

Bristol, April 2, 1883.

[Our readers will be grateful to Professor Thompson for correcting the errors made by the Society of Telegraph Engineers in printing Reis's letter. Whether they will be satisfied with his interpretation of it is not for us to say. For ourselves we have only to remark that our logic—such as it is—is not in the least affected by the emendations, nor by the fact that Edison called his circuit-breaking transmitter a "speaking telegraph" in 1877.—ED. *E.*]

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Referring to your article on the subject of Reis's telephone, and to the copy of the letter reprinted from the *Journal of the Society of Telegraph Engineers and of Electricians*, I beg to point out that the letter in the second line of the fifth paragraph of the reprint should be *c*. This will make the sketch a little more intelligible.

The word "any" commencing the sentence "any sound will be reproduced," &c., in the eighth paragraph should have been printed in italics, the word being underlined in the original letter.—Yours, &c., A. J. FROST, Librarian.

Society of Telegraph Engineers and of Electricians,
4, The Sanctuary, S.W., London, April 2, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The fact that Reis adapted a "little telegraph" with a certain code of "claps" to his telephone in order to "get understood" by his correspondent seems to point to the conclusion that articulate speech could not be transmitted.

It is to be hoped that Mr. Ladd will give fuller and more comprehensive information concerning this remarkable instrument, and so supplement the very ambiguous letter of the inventor.—Yours, &c. W. T. FARQUHAR.

ELECTRIC LIGHT COMPANIES AND THEIR EMPLOYES.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There has been a good deal of criticism lately, both by the electrical world and the public at large, as to the prospects of the various electric light companies, and the way in which they are being managed; and, therefore, I venture to send you a copy of an order which one company has issued to their *employés*, and I think you will agree with me, sir, that if the officers of the said company from whom this order emanates would give their attention more earnestly and heartily to carry out the work in a practical, business-like way, that they would have something more to think of than issuing such an order as this, and trotting about in a haughty, domineering kind of way which is most repulsive both to the men and also the electricians who have charge of the various stations (for I may say that it is not *all* the officers of the company who are like this, as those in charge at stations are highly respected by the men under them); but these in charge are under those who have issued this order, and I may say, in some cases, have also a more *technical* knowledge of the work under them as well. And thus where they are requiring obeisance and respect from the men they are getting the very reverse, and also not only losing their respect but they will be losing their best hands too if this kind of policy is persisted in. The order is as follows:—"To the foreman in charge, ——— station, &c.: Instruct all your men in future when a superior officer of the company visits your station *to touch their hats*; if any man objects report him at once with a view to his immediate dismissal!!!" *(Signature.)* If *this* is what is required to make a man respectful the man had better be dismissed before the order is given, as any man would naturally tender an officer his due amount of respect if the officer knew his place and behaved with that amount of dignity which every gentlemen in such a position would do.

Hoping this will not intrude too much on your valuable space, I beg to remain, yours, &c.,

ONE OF THE WORKMEN SUBJECT TO THE ABOVE ORDER.

London, April 2, 1883.

P.S.—I may also mention that a good many of the men do not even know the said officers.

SOCIETY OF TELEGRAPH ENGINEERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I regret to observe that Mr. Fahie's letter on the Society of Telegraph Engineers has passed unnoticed in your last issue. Surely it is not because the matter of which it treats has no interest for your readers, of whom many must be members of the society.

Leaving out of the question altogether the *éclat* which would redound to the society from the reading of interesting papers at its meetings, the society is a loser in a pecuniary way by the neglect of its distinguished members, of which Mr. Fahie so justly complains. Interesting papers by well known authors always carry large outside audiences, and if occasionally such audiences could be assembled at our meetings, many of their number would end by joining our ranks, and so add to our funds.

While agreeing in the main with Mr. Fahie, I must say that he is a little too unreasonable in wishing that *all* papers on electrical subjects should go to the society. The honour of contributing to the *Proceedings* of the Royal Society is what few men of science can resist; and accordingly when one has the good fortune to have a paper which the Royal Society will accept, he will never take it elsewhere, nor can we blame him.—Yours, &c., J. M.

"WHAT'S IN A NAME?"

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I quite concur with your correspondent, "Brevity," in his observations concerning the inconveniently long title of "The Society of Telegraph Engineers and of Electricians," and am of opinion that it would be most desirable, in this age of progress and rapidity, to adopt some shorter title. I would, therefore, suggest the designation, "Society of Electrical Engineers," which I think would be suitable and meet all the requirements of an institution devoted to the application and development of electricity.—Yours, &c.,

J. ANGELO FAHIE,
Memb. Soc. Tel. Engineers and of Electricians.

10, Leinster-street, Dublin, April 3, 1883.

"UNIPOLAR" DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should like to point out that the term *unipolar* as applied to Ball's new dynamo is a misnomer in more senses than one. According to your diagram on p. 406, it has four poles, one "north," one "south," two "neutral." Further, though there is only one pole-piece for each armature, the machine is not one of the class of true "unipolar" dynamos, like Siemens's "unipolar" machine and Faraday's early rotating disc machine. The term "unipolar induction," so much used by foreign writers for the induction in a sliding conductor revolving round or past one pole of a magnet, though not free from objection, is generally understood, and

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its meaning accepted. Unipolar dynamos are those constructed on the principle of unipolar induction. Ball's dynamo, ingenious as it is, does not come at all within this category. If it were a unipolar dynamo it would require no so-called "commutators." It has, I perceive, two, each provided with a pair of brushes, as in all the common types of direct-current machine, from Pacinotti to Edison.—Yours, &c.,

Bristol, April 2, 1883. SILVANUS P. THOMPSON.

SAFE CURRENT THROUGH COPPER WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: It is so clearly to the interest of all parties that reliable tables of capacities of electric lighting conductors shall be compiled, that I venture to send you for publication a copy of a report addressed to the manager of this company in November last by our consulting engineers, Messrs. Clark, Forde, and Taylor.

From reports made to us we scarcely think it would be safe to rely upon the table contained in your last supplement so far as regards large currents.—Yours, &c.,

H. CLELAND HEYWOOD, Secretary.

The Indian and Oriental Electrical Storage and Works Company (Limited), Winchester House, Old Broad-street.

(Report.)

7, Pope's Head-alley, Nov. 9, 1882.

Dear Sir: In reference to your inquiry of the 20th October as to the amount of current in amperes which could be conveyed by copper wires of different sizes, and to our letters on the subject of the 24th October and 1st November, we beg to say that we have carried out a number of experiments at Millwall, with the result of confirming our view that, up to currents of 10 amperes, or thereabouts, an allowance of 10lbs. of copper per mile for each ampere of current will be quite safe, so far as regards risk of injury to the insulating material, even though the wire be enclosed in asphalte, sand, or other such imperfect conductors of heat.

This, however, would not be true for currents very much greater than 10 amperes.

We find in such cases that, when the insulated wire is surrounded by a bad conductor of heat, there may be a rise of temperature sufficient in time to injure the insulator, though not if the insulated wire be freely exposed to radiation.

Our experiments show that the law cannot be stated so simply as "so many pounds per mile per ampere," owing to the fact that the heat developed is directly as the area of section of the wire, whilst the loss of heat by conduction only takes place in proportion to the surface of the wire. It is evident that the heat in large wires must accumulate, and the temperature rise more than in small ones.

Our experiments, in fact, show that with wires of different sizes, carrying currents of, say, one ampere for each 10lbs. of copper, the larger wires will attain a higher temperature than the smaller.

We have found experimentally that if the safe limit of rise of temperature in a wire whose weight is (w) lbs. per mile is reached when it conveys (n) amperes of current, then the same limit is attained in another wire carrying (m) amperes when its weight

$$W = w\left(\frac{m}{n}\right)\frac{4}{3}$$

Small wires will, therefore, safely carry currents having a greater relative proportion to their weight than large ones.

On the assumption that 10lbs. per mile per ampere is a safe limit up to, say, 13 B.W.G., we have calculated a table of current for several B.W.G. sizes of copper wire, which will serve practically for either solid or strand conductors.

Our letter of the 24th October dealt with the question of economy as regards interest on first cost, and we there stated in whole numbers that if we allow 10lbs. of copper per mile per ampere, one horse-power is wasted for each eight amperes of current per mile, whereas if 20lbs. of copper be allowed the waste is reduced to one horse-power for each 16 amperes per mile, and so on.

We have gone into the question of interest on first cost, assuming that the consumption of coal per indicated horse-power was 3½lbs., and its cost 40s. per ton in India. Allowing twelve hours work per day, the cost of horse-power is therefore £13 6s. 8d. per annum, and we assume the cost of the electrical horse-power to be double this, or £27 per annum, owing to the loss in conversion through the dynamo and accumulators.

The cost of insulated conductors we take from the known price of a conductor weighing 448lbs., viz., £50 or £0·112 per lb., and we assume the annual interest and renewal on first cost to be 10 per cent.

From these data we calculate that the most economical employment of insulated copper wire in India would be to use about 55lbs of copper per ampere per mile (Professor Sir Wm. Thomson gives 63lb. per mile). If we could halve the above cost of horse-power, this would reduce the weight to 40lbs. per mile; in fact, the question is one which requires calculation in each special case, the formula being

$$W = A \times 10{\cdot}75\sqrt{H}$$

W being the total weight in lbs. per mile,
A the current in amperes,
H the cost per annum of the horse-power.

From these considerations it is obviously economical to use large conductors, and it is even more economical to use high electromotive force, since you can by this means transmit the same amount of work with fewer amperes of current.—Yours, &c.,

(Signed) Clark, Forde, and Taylor.

T. M. Collet, Esq.,
Indian and Oriental Electrical Storage and Works Company (Limited).

LITERATURE.

Physics in Pictures. The principal natural phenomena and appliances described and illustrated by thirty coloured plates, for ocular instruction in schools and families. With explanatory text, prepared by T. ECKARDT, and translated by A. H. KEANE, M.A.I. [Edward Stanford. London: 1882.]

Those who have any interest in the education of children will welcome this book as an aid to instruction. The proficient in science prefers possibly a diagram to a coloured picture, but a child prefers the picture to the diagram—pores over the picture, knows every square inch of surface, and so carries the picture in his mind as to illustrate any similar phenomena he comes across that is depicted by it. We have here some thirty sheets of brightly-coloured pictures, which appeal to the eye. In a few instances the apparatus depicted is old fashioned, but as a rule the lessons that it is desired should be learned are well illustrated. The fire engine depicted may be of a type a little out of date, but the principle is the same as in the engine of the most recent type. Explanatory letterpress accompanies these pictures, but we should imagine that the parent or teacher had better depend upon his or her own knowledge of the subject than upon letterpress. The child learner has an inconvenient habit of asking for information that is not supplied by letterpress, and is highly delighted if the teacher will just answer questions, and not attempt to go through a set description. We have tried the effect of putting this book into the hands of children, and we are quite satisfied that it is of very great use. Try to explain "centre of gravity" to a boy of eight without apparatus or diagram, and note the result. Now try again, but aiding explanation with experiment; put the boy on one leg, put him upright against the wall, heels and shoulders touching the wall; let him have a first attempt to stand on his head, and he will soon realise the why and wherefore of the positions as shown in Plate I. of this work. A few ideas really grasped by the aid of experiments will expand the mind sufficiently to enable it to grasp

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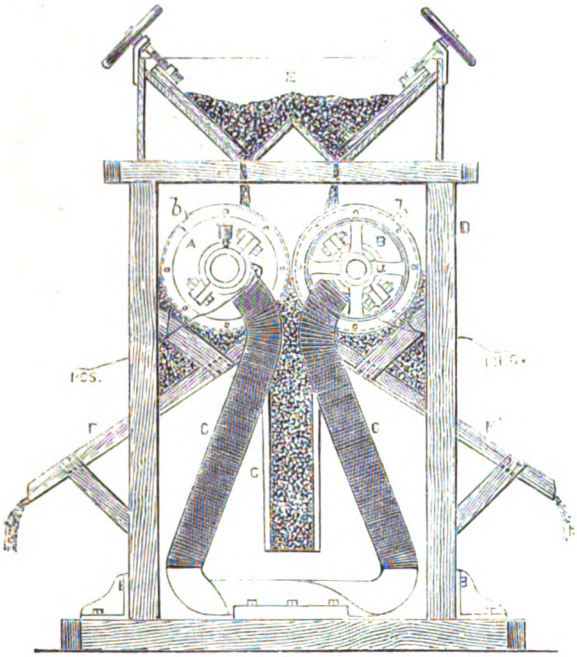
many of the principles illustrated in this book. The teacher must be a living teacher, having a mind of his own, able to take advantage of a gleam of light shown by the questioner, and then he will appreciate the aid of such a book as the one Mr. Stanford now presents to us. We shall not enter into a detailed criticism of each sheet of pictures, but accept the broad fact that many fundamental scientific principles are fairly illustrated. The scale of the pictures is large, and thus the parts are easily seen, and the colouring is clear.

THE BUCHANAN MAGNETIC SEPARATOR.

Among the many recent applications of electricity to the arts, one of the most interesting to those engaged in mining and metallurgy is that of concentrating ores. Though repeatedly attempted, particularly for magnetic iron ores, by the use of permanent magnets, it was not until the perfection of dynamo-electric machines permitted the economical generation of electric currents that any work worthy of serious attention was done. Naturally, the first field in which any effort was made was in the dressing of magnetic iron



The Buchanan Separator.

ores, and sands containing that ore, and in this direction the greatest progress has been made in this country. It may be of interest, however, here to recall the fact that, at a number of places abroad, magnetic separation has been extended to other classes of ores, notably close mixture of spathic iron ore, or iron pyrites and blende, previously roasted, as it is possible that by this remain similar ores, now useless, may be made available here. The principal field of magnetic separation will, however, always remain the dressing of magnetic iron, sands, and ores. In the case of the former, drying in a suitable revolving cylinder is resorted to, while with the latter class of material a system of crushing, pulverising, and sizing is necessary. Mr. C. G. Buchanan, of this city, the inventor of the machine we are about to describe, has shown us a sketch of a mill for this purpose, in which he has, by suitable exhaust arrangements, provided for the removal of the dust made during the crushing and screening, which would prove objectionable in the later separation. The principal market for fine magnetic ore, obtained by this system of dressing, is, of course, for forge fires and puddling furnace fix, the quantity which could be used in blast furnaces being limited by the inconvenience which raw material of such fineness would entail in the working of the furnace.

The Buchanan magnetic separator, which we illustrate this week, has been at work for upwards of two years on sands, at Block Island, and possesses features of special interest. A and B represent the two cast-iron rolls, provided with heavy wrought-iron shafts or journals. In section, these rolls have an oval core, so that the surface of the rolls is uniformly magnetic. The distance between the surface of the two rolls is two inches. C C represent the iron standards supporting the rolls, and having journals in which they revolve. The rolls are provided with brass collars, *b b'*, intended to prevent the ore from dropping outside of them. D represents the wooden frame to which the stands are bolted, and it also supports the hopper E, and the chutes F and G. The standards C are first insulated and then closely wound with heavy insulated copper wire, and the two ends of the wire are connected with the poles of a dynamo machine. It is evident that, if a strong current of electricity is passed through the wires, the standards C will become powerful electro-magnets, and that, if they are properly wound, each end of the same standard will be of opposite polarity, as indicated by the wires marked positive and negative. It is also evident that the rolls will be charged by induction, and that one roll will be of north polarity, and the other south. The peculiarity of this arrangement is, that a powerful magnetic field is formed between the rolls, and they are capable, while charged, of holding a weight of 500lb. or 600lb., if it is placed between them, while on their opposite side they are practically non-magnetic, and will not hold a tack.

The variations needed in dressing ores of different grades and sizes are controlled by regulating the power of the current of the dynamo-electric machine. The latter is of a special pattern, producing a current of a low electromotive force, the wire being heavier, and larger electro-magnets being chosen. It is built by the well-known Weston Electric Light Company.

The operation of the machine is as follows: The rolls are rotated towards each other, at a circumference speed of 150ft. per minute, and the hoppers opened so that the ore falls upon the top of the rolls. In passing over the rolls it is carried through the magnetic field, and all that is magnetic is attracted and attached to the faces of the two rolls, and carried around by them to a point where they lose their magnetic effect, and the ore falls into the chutes F F. The rock, being acted upon by gravity alone, falls directly into the chute G, and a nearly perfect separation is thus effected.

The Union Foundry Company, of Rockaway, N.J., which builds these machines for Mr. C. G. Buchanan, the inventor, manufactures three sizes, the largest having rolls 24in. in diameter and 36in. long, with a capacity of treating 100 tons of ore per day, and larger quantities of sand. The range of sizes seems to be considerable. We are informed that ores as fine as from 40 to 60 mesh, and as coarse as from 8 to 10 mesh have been treated successfully.—*Engineering and Mining Journal*, New York.

ON THE INFLUENCE OF THE CHEMICAL NATURE AND DENSITY OF ABSORBED GASES UPON THE ELECTRICAL CONDUCTIVITY OF CARBON.

(Preliminary Note.)

BY ALFRED W. SOWARD AND I. PROBERT.

It has long been known that carbon has the power of condensing gases within its pores. De Saussure, who first investigated this absorptive power, found that at 12deg. C. and under 724 mm. pressure a piece of boxwood charcoal, which had been previously heated to redness and then cooled under mercury in order to remove air from its pores, would absorb 90 times its own bulk of ammonia, 35 of carbon dioxide, 9·25 of oxygen, 6·50 of nitrogen, and 1·25 of hydrogen. Hunter, who has examined the subject more recently (*Phil. Mag.* [4], XXV., 364; XXIX., 116) has found that a piece of porous (cocoa-nut) charcoal at 0 deg. C. and 760 mm. pressure, would absorb 171·7 times its own bulk of ammonia, 67·7 of carbon dioxide, 17·9 of oxygen, 15·2 of nitrogen, and 4·4 of hydrogen. From these figures it will

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be seen that the more readily condensable the gas the larger is the quantity absorbed, and the experiments of Malsen (*Comptes Rendus*, LXXVI., 81, 92), seem to prove that some gases at least are actually reduced to the liquid state within the pores of the carbon.

Graham discovered that certain metals have the power of absorbing or "occluding" many times their own bulk of hydrogen; palladium, for instance, at the ordinary temperature absorbs 376 volumes of that gas. This absorption was found to be accompanied by an increase in the bulk of the metal, and a decrease in its electrical conductivity.

Although the analogy between the occlusion of hydrogen by metals (accompanied in all probability with the formation of definite alloys) and the absorption of gases by carbon (in non-atomic proportions) is not perfect, there is still sufficient resemblance for the question to be suggested whether the electrical conductivity of carbon may not be affected by the absorption and liquefaction of large quantities of gas in much the same way as that of palladium is affected by the occlusion of large quantities of hydrogen.

We have during the past year been conducting a series of experiments having for their object the preparation of an extremely dense and non-porous carbon for electrical purposes. In the course of these experiments we have had the opportunity of measuring the electrical conductivity of samples of carbon in atmospheres of different gases at various pressures; and we have found that the conductivity of a piece of porous carbon is not a constant for a given temperature, but varies with the nature of the gas surrounding it (and consequently absorbed in its pores), and also with the pressure of that gas. The conductivity of a piece of porous carbon would not be the same at the summit of Ben Nevis as at its foot; it would not be the same in the air of Hyde Park as in the fire-damp laden air taken from a coal mine. This variation of the conductivity of carbon with variation of pressure we have found to be a very convenient test of porosity.

It has been said that there is an essential difference between the resistance of a pile of carbon powder and the resistance of a block of carbon, that the first resistance is not a true resistance, as it is not constant for currents of different strengths; the air spaces between the particles of carbon powder are stated to be the cause of this. But we venture to think that the heap of carbon powder is but an extreme case of porosity, and that it would be possible to prepare a series of carbons which should range in porosity (and in properties dependent upon porosity) from the dense carbon whose resistance is practically constant for all pressures, through many intermediate stages, without break of continuity, to the heap of carbon powder whose porosity is a maximum.

Experiments are in contemplation to determine quantitatively the variation of the conductivity of different varieties of carbon with variation of the chemical nature of the absorbed gas and with variation of its density.

HISTORIC NOTES ON THE TELEPHONE.

BY J. J. FAHIE, MEMB. SOC. TEL. ENG. AND ELEC.

Seeing of late a good deal about the telephone in the pages of *The Electrician*, it has occurred to me that a few facts on its early history would not be uninteresting. I therefore give below such notes as I have been able to collect in the course of my researches in dusty tomes. Many of the references will, doubtless, be familiar to those of your readers who have studied the telephone, but a few will, I think, be regarded as "facts not generally known."

Passing over the claim of the Chinese to the invention of the telephone as "not proven," we come to the year 1837, when Professor Page, of Salem, Massachusetts, observed the sound that was produced in iron by magnetisation and demagnetisation. This phenomenon was explained by De la Rive, of Geneva, in 1843, who showed that it was caused by the slight elongation of the iron which accompanies the act of magnetisation, a fact discovered by Dr. Joule in 1842. Page's receiver consisted of a bar of iron surrounded by a coil of wire. These bars were of considerable dimensions, some as much as 3ft. long and 1in. to 2in. diameter. With powerful currents the sound emitted was heard as a click, and when these clicks were made to follow each other with sufficient rapidity a certain note was produced whose quality depended, of course, on the number of clicks per second. By an automatic make and break arrangement as a transmitter, Page obtained sounds sufficiently loud to be heard at a considerable distance.

The next step in the evolution of the telephone is claimed for Mr. Edward Farrar, of Keene, New Hampshire, U.S. His proposal was to transmit sounds of different pitches by the vibration of an armature of an electro-magnet. The *modus operandi* is thus described by the author himself in a letter written in 1851, and which his friend Mr. Brackett published in *The Scientific American* in 1879:—"Each reed of a melodeon is furnished with a small metallic point, which, while the reed is at rest, approaches near to the surface of mercury in a very small cup underneath the reed, into which the point dips when set in motion. The reeds are connected with one pole of a battery, and the cups with the other. The current is broken with each vibration of the reed. At the remote end of the wire is a temporary magnet, with an armature fixed upon a spring in near proximity to the magnet, and which is affected as a reed at the other end of the line is set in motion. The effect is that the armature vibrates with the reed set in motion, and, as the pitch of a sound depends on the rapidity of vibration, it will be the same in the reed and armature. A tune on the instrument will, therefore, produce a tune on the armature. What may appear somewhat strange, several different tones may be heard when chords are struck upon the instrument. The object of my inquiry was this: If the current power could be varied by some slight variation of a vibrator to be affected by the atmosphere as the tympanum of the ear is, the supposition is that the sounds of the voice might be reproduced by the means stated above."

Professor Dolbear says, in his paper "On the Development of a New Telephonic System," read before the Society of Telegraph Engineers and of Electricians, March 23, 1882:—"Though Farrar spent some time in attempting to solve the problem of the transmission of speech by electricity, he did not succeed. He had some written communication with one of the foremost men of science in New England at that time (1851) as to whether such a device could be made, and as to its practicability, but the reply he received was so discouraging that he abandoned the attempt."

The next attempt was a musical telephone again, the invention of a M. Paterna, of Prague, about 1852. It was a keyed instrument, which, by means of an electro-magnet, set a small iron plate or armature in vibration as soon as the hand left the key. Each key gave a different note, and a similar instrument at a considerable distance was caused, by a connecting wire, to give out the same tones. This apparatus is described in Dingler's *Polytechnisches Journal* for 1852, also in Böttger's *Polytechnisches Notizblatt* for 1853.

In the *Builder* for May 5, 1855, there will be found a reference to the submarine cable then just laid between Varna and Balaclava, in the course of which occurs the following remarkable passage:—"It would not now be difficult, by some little further novelty of invention, to cause the reverberation of the very cannons themselves, as it were, to be transmitted, in the shape of electric vibration, through the 3,000 miles of intervening wire, and heard, in still continuous vibrations, finally communicated to some acoustic apparatus in the British Houses of Parliament! Such is the close co-relationship of forces, that this is literally perfectly possible; and, although it would not be precisely the sound of the cannons which our legislators would hear, it would actually be the vibratory reverberations of that very sound itself, for all sounds are vibratory forces, which reverberate into the electric interiors of material substances; and some recent experiments have curiously illustrated this very point in physical science."

Our next reference is of a similar kind to the last, a mere expression of opinion, on theoretical grounds, of the possibility of transmitting the human voice to a distance by the agency of electricity. *Apropos* of this M. le Comte du Moncel (*Exposé des Applications de l'Électricité*, Paris, 1857) has the following, which to-day reads strangely enough:—"I did not wish to bring forward in the chapter on the electric telegraph a fantastic conception of a certain M. C. Boursel, who believes that it will be possible to transmit speech electrically, because it might have been asked why I had classed among so many remarkable inventions an idea that is not more than a dream?" "The idea that is not more than a dream" is thus described in the same work:—"Imagine that one speaks near a mobile plate, flexible enough not to lose any of the vibrations produced by the voice; that this plate establishes and interrupts successively the communication with a battery. You may be able to have at a distance another plate which would execute at the same time the same vibrations. It is true that the intensity of the sounds produced would be variable at the point of departure where the plate is vibrated by the voice, and constant at the point of arrival,

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where it is vibrated by electricity. But it is demonstrable that this would not alter the sounds."

The next note is a mere newspaper paragraph, and is to the following effect:—"The Abbé Laborde, in a paper read before the French Academy, and printed in the last number of the *Comptes Rendus*, showed how vibrations may be transmitted and reproduced at a distance by electricity—April 14, 1860." Against the same name in Ronalds' catalogue we find the following entry:—"Note on a New Electric Telegraph, whose indications are given by means of sound" (*Comptes Rendus*, XXI., 526, Paris, 1845).

The experiments of Professors Wheatstone and Helmholtz, in which were employed tuning-forks in connection with electro-magnets, are so well known as to need only the briefest mention here; we will therefore pass on to a consideration of the labours of Reis, who comes next in the order of time. As the back numbers of *The Electrician* contain all that can be said about Reis's *latest* improvements in telephony, his *earlier* labours, being not so well known, and not less interesting, will solely occupy us here.

According to a letter which Dr. Messel, a former pupil of Reis, addressed in December, 1877, to Professor Barrett, of Dublin, Reis's first experiments date as far back as 1852. But at that time they ended in failure, and were not resumed until 1860, about which time the first published account of them appeared in a daily paper of Frankfort-on-Main.

"The first instrument," says Dr. Messel, "was of a most primitive nature. A bung of a beer-barrel had a conical orifice cut through it, the smaller end being closed with the skin of a German sausage, which did service as a membrane. To this was fixed, with a drop of sealing-wax, a little strip of platinum (or a platinum wire) representing the hammer of the ear, and which closed or opened the circuit precisely as in the instruments of a later date. The receiving instrument was a knitting needle, surrounded with a coil of wire, and placed on a violin to serve as a sounding board. Some idea of the roughness of the main parts of the first telephone can thus be formed. When first exhibited at Frankfort it astonished every one quite as much as the more perfect instruments of Bell now do. The apparatus here described has now passed into the hands of the Telegraph Department of the German Government."

Reis gave his first public lecture in October, 1861, before the Physical Society of Frankfort-on-Main, an account of which is published in the annual report of that society for the year 1861. It is entitled "Telephony by Means of Electric Currents." He describes the way in which he was led, from the study of the human ear, and the manner in which it receives the impression of vibratory movements, to the construction of an instrument similar in principle, which should reproduce musical tones and even the sound of the voice in speaking.

A cubical wooden block was pierced by a conical opening, the smaller end of which was covered by a thin skin, and to the centre of this skin was fastened a narrow strip of platinum, joined to one end of a small voltaic battery. Close to, but not touching this strip, was a wire connected to the distant receiver, returning thence to the other pole of the battery. His receiver was still a simple knitting needle surrounded with a coil of wire, and supported upon a resonant box. Speaking into the broad end of the cone, the membrane was thrown into vibration, and intermittent currents were sent to the distant receiver. Here the rapid magnetisation and demagnetisation of the iron core by the interrupted current gave rise to a series of sounds. Here are his own words as to the performance of this early form of instrument:—"I was able to make melodies audible to a numerous audience at the Physical Society of Frankfort-on-Main. Melodies were sung, not loudly, into my apparatus in a hospital about three hundred feet away from the listeners, care being taken that no sound could be heard by direct means, or by conduction along the wires. The sounds of various musical instruments were also clearly reproduced, as the clarionet, horn, organ-pipe, and even harmonium or piano, when the transmitter was placed on their sound-boards, provided the tones were within a compass of about three octaves—F to f''' So far, articulation has not been reproduced equally well. Consonants, however, were in general pretty clearly heard, but not the vowels. The sound, in all cases, is of course much feebler than in the originating instrument."

Subsequently Reis achieved greater success in reproducing articulation. In a report of Reis's telephone by a M. Legat, Inspector of Telegraphs in Cassel, &c., published in 1862,* the following sentence occurs:—"Melodies can be reproduced with astonishing certainty, whilst single words, in reading, speaking, &c., were less distinct, although the peculiar modulations of the voice in speaking, calling, interrogation, surprise, or command were clearly marked." The instrument described in this report is somewhat different from the earlier form. The diaphragm was a collodion film, and the contact-breaker behind it was lighter, and constructed in the form of an S-shaped lever, the longer arm of which was in contact with the membrane, while the shorter made and broke the circuit. There was no metal disc on the membrane, but the circuit was completed by means of the arm on which the lever delicately moved. The receiver, moreover, was a small horse-shoe electro-magnet, fixed horizontally to a sounding board. The rapid isochronous movement of a light keeper, adjusted by a spring before the poles of the magnet, reproduced the original sounds.

Still more success as regards articulation appears to have been achieved a little later; for, in a paper on Reis's improved telephone, published in Germany in 1863,* it is stated:—"Particularly distinct was the reproduction of the scale. The experimenters could even communicate to each other words; only such, however, as they had already heard frequently." In confirmation of this may be added the following extract from a recent letter received from Dr. Messel:—"There is not a shadow of a doubt about Reis having actually achieved imperfect articulation. I personally recollect this very distinctly, and could find you plenty of ear-witnesses to the same fact."

Two or three years later, in 1865, a skilful instrument maker in Dublin, Mr. Yeates, showed to the Philosophical Society in that city a modification of Reis's telephone, wherein a near, though accidental, approach was made to the true principle of an articulating telephone—namely, the employment of a continuous electric current of varying strength. This was obtained, though the primary object was different, by putting a drop of water or a fragment of moistened paper between the metal disc on the membrane and the adjacent platinum point which completed the electric circuit. Articulation of an imperfect kind was thus obtained. Unaware of Reis's improvements, Mr. Yeates also employed a simple and a very effective form of electro-magnetic receiver, which deserves to be more widely known. Upon a light sounding-box a little electro-magnet is supported by a brass pillar. A light iron keeper is fastened at one end by a flat steel spring to a wooden bridge, which can be raised and lowered by a screw. The distance of the keeper from the poles of the magnet can thus be adjusted with great nicety—a point of some importance. The ends of the wire round the coils are connected with binding-screws, to which are joined the line wire leading to the distant receiver and the return wire. With this little instrument an audience of a thousand people can easily hear musical airs sung into the transmitter, which may be many miles away.

In conclusion of this portion of our subject we have to acknowledge our obligations to a paper on the Electric Telephones of Reis and Bell, contributed some years ago by Professor Barrett to *Good Words*.

About the same time that Yeates, in Dublin, was introducing improvements into the Reis telephone (one of which, the water contact, would almost entitle him to a share in the discovery of the undulatory principle since appropriated by Bell) an Italian mechanic, named Manzetti, appears to have designed an instrument for the same end. Unfortunately, we have no more information respecting this invention than is contained in the following extract from the *Petit Journal* of Paris, November 22, 1865:—"A new discovery, which will produce immense results in its application to the arts and industries, has recently been added to the numerous wonders of this century; it is the transmission of the sounds of the voice by telegraph. The author of this invention is Signor Manzetti, of Aosta, who is also the inventor of a celebrated automaton. He transmits words with the ordinary telegraph wire, and with an apparatus more simple than that which at present serves for despatches. Henceforth, two merchants may communicate instantaneously their business affairs between London and Calcutta, informing each other of their speculations, agreements, &c. A number of successful experiments have been made, which confirm the practicability of this invention. It also transmits musical notes, &c."

Our next note refers to a claim which is equally vague as the last, and rests upon still more slender foundations, to wit, the *ex post facto* statements of the claimant himself. In saying this we do not by any means wish to insinuate that these statements are unworthy of credence. We give the paragraph as we found it in the *Journal of the Telegraph*, for May, 1877, leaving it to our readers to draw their own conclusions:—"There is another claimant in the field for the honour of inventing the telephone. Dr. James Davis, of Salisbury, N.C., writes to the *Raleigh Observer*, stating that his 'phonetic telegraph,' invented ten years ago, anticipated the discoveries of Messrs. Bell, Gray, and others. Dr. Davis says that he made pen-and-ink drawings at

* See the *Journal* of the East German Telegraph Company of that date, or the reprint of the paper in 1863 in Dingler's *Polytechnisches Journal*, vol. clxix, p. 29.

* See No. 15 of Böttger's *Polytechnisches Notizblatt*.

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that time, fully illustrating his invention, and that he described his apparatus to persons whom he names. He declares that his device covered the changing of air vibrations into those of electricity, and restoring the air waves after transmission; that his apparatus was more perfect than that which the present inventors exhibit, and that it could write or register the sounds in a distinct language."

Our last quotation is from a source where one would least expect to find it, viz., in the post-prandial oration of a Minister Plenipotentiary! At a grand banquet given to Professor Morse in December, 1868, Sir Edward Thornton, then our Minister at Washington, said, in the course of his response to the toast of his Sovereign, "Should I have the good fortune to live to the age of the venerable professor, I hope to see some such improvements as will enable us to carry on *vivâ voce* conversation by means of the cable. We shall then have merchants on this side of the water discussing their affairs with those of the other at so much a minute. We shall hear, perchance, of some love-stricken youth of London or Paris whispering soft nothings along the cable to one of those bewitching syrens of New York at so much an hour, she tempting him all the while to throw himself into the gulf which separates them. We shall have statesmen, aye, and in those days of progress, even stateswomen, discussing international questions at so much a conference, and we poor diplomatists shall run a very good chance of being exploded altogether."

Considering the occasion, many people would, perhaps, pass by these sentiments with a sneer, characterising them as mere fantastic conceptions, as ideas that are not more than a dream, if, indeed, they would limit themselves to expressions so mild; but we, having the sad fate of the Comte du Moncel before our eyes, and being still on the right side of forty, hesitate to adopt this course. The British Minister, of course, spoke in jest, but we, seeing that more unlikely things have come to pass, may echo his sentiments in earnest.

THE TRANSMISSION OF POWER BY MEANS OF ELECTRICITY.*

(CONCLUDED FROM PAGE 479.)

As a supplement to the foregoing figures, I have the honour of communicating the results of the second series of experiments, which were made on the 18th February at the Northern Railway workshops, with M. Marcel Deprez's instruments and the same installation. Nothing had been changed as regarded the apparatus, and it was proposed merely to again ascertain the work done, giving the shaft of the generator a speed of about 900 revolutions per minute—that is an increase of one-half on that of the trials on the 11th February. The observations were carried out as before, except that the electrical readings were obtained with Deprez galvanometers under the control of my *confrère*, M. Cornu, who kindly undertook this duty. Five experiments only were made under ordinary working conditions, the object of the first being the determination of the work expended in working the generator idle only. The eighth must be put aside, as, the paper having broken, the dynamometer pencil could give no indications, and the seventh must be pointed out as less accurate than the others as far as the motive power is concerned.

The data collected were as follows:—

The Measurement of the Current.—The indications of the current galvanometer in the circuit of the dynamos and the telegraph wire oscillated during the whole of the experiments between 10·5 divisions and 11 divisions, or an average of 10·75 divisions, which correspond, according to the constant of the instrument as given by M. Deprez (1 div. = ·25 ampere), to a nearly constant current of 2·687 amperes. This will be found to be in accordance with the other figures.

The Measurement of the Difference of Potential at the Terminals of the Machines.—The current in a shunt circuit taken from the terminals of each machine, and composed of a known resistance, 50,000 or 30,000 ohms successively, was measured by a sensitive galvanometer having a resistance of 56 ohms. (This figure was given by M. Deprez.) The constant of the instrument, 1 div. = $\frac{1}{220}$ ampere, enabled us to calculate the electromotive force in volts for each observation, by means of either of the formulas,

$$E = \frac{n}{220}(50{,}056), \text{ or, } E = \frac{n^1}{220}(30{,}056).$$

* Report on the Results of the Experiments made by M. Deprez in the workshops of the Northern (of France) Railway, presented to the Paris Academy of Science by M. Tresca.

Below (Table III.) are given the direct readings obtained:—

TABLE III.—Readings of the Galvanometer.

No. of the Experiment.	Zero of the Galvanometer.	Resistances added. 50 000 ohms. Generator.	50 000 ohms. Receiver.	30 000 ohms. Generator.	30 000 ohms. Receiver.
VI.	− 1·25	+ 6·50	− 7·50	+ 11·75	− 11·60
VII.	− 1·50	+ 5·00	− 6·60	+ 9·60	− 10·00
IX.	− 1·55	+ 7·50	− 8·90	+ 13·80	− 13·80
X.	− 1·55	+ 7·75	− 8·95	+ 13·90	− 13·90

The values of the deflections, n and n^1, which result by means of addition for the two machines respectively, should for each of them show a constant relation for $n : n^1$, and the verifications of this relation serve to show that the constants of the instruments remained very steady during the experiments. By introducing the values of n and n^1, deduced in this way, into the above equations, which give the corresponding values of E, the electromotive force between the poles of each of the machines can readily be obtained.

The measurements having given almost identical results as regards the E.M.F. at each experiment, the averages given in Table IV. may be trusted:—

TABLE IV.—E.M.F. IN VOLTS.

—	Generator.			Receiver.			—
No. of Experiment.	R = 50,000.	R = 30,000.	Averages.	R = 50,000.	R = 30,000.	Averages.	Ratios.
VI.....	1763	1776	1770	1422	1414	1418	·801
VII. ...	1479	1516	1498	1160	1161	1161	·775
IX. ...	2059	2097	2078	1672	1673	1673	·805
X.	2116	2110	2113	1684	1687	1687	·798

Measurement of Mechanical Work.—The same dynamometer and the same brake which were employed on the 11th February were again used. The results of the four complete experiments are given in Table V., which is similar in form to those already given. The relation between the speeds of the receiver and generator was in this case 395 : 814 = ·743, whereas in the experiments made on the 11th February it rose to ·620 only. Table V. shows at a glance the losses at each point of the circuit. I shall endeavour to offer some explanations which the figures in the table seem to call for.

1st. The figures for the work in experiment VII. are rather uncertain, although the mean ordinate of the diagram was made over a length of about two metres.

2nd. The work recorded when running idle was in this case much greater than in the first series of experiments; the belts had certainly been tightened up, and were too taut. Each revolution of the dynamometer corresponded to a work of ·0172 horse-power, whilst in the first series we found it to be ·004 horse-power. However this may be, the 2·196 horse-power (see Table VI.) comprised the friction of belts and resistances, counter shafting, &c. If, indeed, any magnetisation existed or was produced when running idle, this work would also have been registered. It would be necessary in all cases occurring in practice to look from the speed of the motor shaft to that of the generator, and in almost all cases it will be found that the resistances are of the same class. As regards the electric work, however, and the losses which it sustains, it is necessary to make a separate calculation for this loss of transmission.

3rd. This deduction having been made from the motive power, the power at disposal is reduced to 8·193 horse-power over 10·389, or to ·789 of its primitive value as measured on the dynamometer.

4th. The heat which would be produced on the expenditure of this motive power by the passage of the current in the generating machine, the resistance of which when idle and cold was 56 ohms, represents a fall in the power equal to ·549 horse-power, common to all the experiments.

5th. Experiment proves that there is another and supplementary fall in power which occurs between that absorbed by the generator and that lost in the circuit by the current; this loss reaches on an average ·844 horse-power, and represents all that has not been reckoned in calculating the heat developed in the generator. Is the resistance of this generator greater when

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TABLE V.—Giving data for all the experiments.

Nos. of the Diagrams.	Dynamometer.				Current	Generator.			Receiver.			Brake.	
	Mean Ordinates of the Diagrams.	Revolutions per minute.	Work in kilogrammetres.	Work in h.-p.	In amperes.	E.M.F. in volts.	Revolutions per minute.	Electric work in h.-p.	E.M.F. in volts.	Revolutions per minute.	Electrical work in h.-p.	Work transmitted in h.-p.	Efficiency.
	mm.												
VI.	15·39	127	751·92	10·025	2·687	1770	792	6·462	1418	578	5·177	3·211	0·320
VII.	15·77	111	673·42	8·978	2·687	1498	705	5·468	1161	488	4·239	2·711	0·304
IX.	15·84	138	840·93	11·212	2·687	2078	876	7·586	1673	650	6·108	3·611	0·322
X.	15·93	138	845·70	11·274	2·687	2113	883	7·714	1686	663	6·155	3·683	0·326
Totals ...	62·93	514	,,	41·489	,,	7459	3256	27·230	5938	2379	21·679	13·216	1·269
Averages	15·73	128·5	,,	10·395	,,	1865	814	6·808	1485	595	5·420	3·304	0·317
VIII. ...	*x*	126	*x*	*x*	2·687	1853	814	6·765	1364	620	4·980	*x*	*x*
V.	3·36	118	152·95	2·029	and ·0172 horse-power per revolution when running idle.								

TABLE VI.—Giving data of the work measured at different points of the installation.

NOS. OF THE EXPERIMENTS.....	VI.	VII.	IX.	X.	Totals.	Averages.
	h.-p.	h.-p.	h.-p.	h.-p.	h.-p.	h.-p.
1. Motive power measured at the dynamometer	10·025	8·997	11·211	11·324	41·557	10·389
2. Power expended in mechanical transmission, including the shaft of the generator	2·173	1·896	2·358	2·338	8·785	2·196
3. Mechanical power actually supplied to the generator	7·852	7·101	8·853	8·966	32·772	8·193
4. Electric power expended owing to the resistance of the generator.....	0·549	0·549	0·549	0·549	,,	0·549
5. Loss of supplementary work (by difference).....	0·879	1·091	0·712	0·696	3·378	0·844
6. Electric power leaving the generator.....	6·424	5·461	7·592	7·721	27·198	6·799
7. Power expended in heat in the circuit	1·243	1·218	1·479	1·561	5·501	1·373
8. Electric power entering the receiver	5·181	4·243	6·113	6·160	21·707	5·426
9. Electric power expended owing to the resistance of the receiver.....	0·814	0·814	0·814	0·814	,,	0·814
10. Loss in supplementary work (by difference)	1·156	0·718	1·688	1·673	5·235	1·309
11. Mechanical power transmitted to the shaft of the brake	3·211	2·711	3·611	3·683	13·216	3·304

working with a closed or interrupted circuit? Within what limits do the brushes loose the current? What is the loss through sparking? Are opposing currents produced which increase the resistances? Such, and such as these, are the questions which we only glance at generally, leaving their solution for further study.

6th. Did the current made to traverse the telegraph wire which connected the two stations invariably represent only 6·799 horse-power, that is to say ·654 of the motive power, or ·829 of the power at disposal on the shaft of the generating machine?

7th. In traversing the telegraph wire of 17 kilometres in length and of 160 ohms resistance, the energy transformed into heat should represent $\frac{\overline{2\,687}^2 \times 160}{g}$ kilogrammetres, or 1·570 horse-power; we found the average difference between its exit from the generator and arrival at the receiver to be 1·373 horse-power only. Having regard to the small variations in the current, which were not measured during the course of the experiments, these two values may be taken as identical.

8th. The observations made at the motor showed that the current represented there but 5·424 horse-power, that is ·522 of the original motive power, or ·662 of the mechanical power at disposal at the shaft of the generator.

9th. The resistance of the receiver, taken as 83 ohms when idle, corresponds to a transformation of ·814 h.-p. of energy into heat, which is indicated in the 9th entry in Table VI.

10th. But this does not nearly correspond with the difference between the motive power of the current on entering the receiver and the work expended in friction on the brake attached to its shaft. The difference, which amounts to 1·309 h.-p., should be attributed to the causes already enumerated in paragraph 5, and to which must be added the passive resistance of the shaft of the receiver, no direct value for which was obtained as in the case of the generator. This loss would seem to have notably increased during the high electromotive forces generated in the second series of experiments, and a portion of this increase must without doubt be attributed to sparking.

11th. Finally, we come to the work measured at the brake, the average of which was only 3·304 h.-p., that is ·318 of the motive power, or ·403 of the power at disposal at the shaft of the generator. The work expended in the shape of heat, and necessarily lost, may be added as follows :—

	H.-P.
In the generator	·549
In the intermediate circuit	1·373
In the receiver	·814
Total	2·736

This is equal to ·263 of the mechanical power expended, or ·334 of the power at disposal at the shaft of the generator.

On the other hand, the losses which cannot be calculated reached

	H.-P.
In the generator	·844
In the receiver	1·309
Total	2·153

Which form ·207 of the total power, or ·263 of the mechanical power at disposal at the shaft of the generator.

The figures can be grouped in yet another way :—

Power absorbed in transmission	·211
Power lost in heat developed by resistances	·263
Power lost of necessity at the points of transformation...	·207
Power actually transmitted	·318
Total	1·000

The attention of makers should be given to these figures, and efforts made to minimise the losses so as to approach an efficiency of 50 per cent.

If we examine experiments IX. and X. in the same way we shall obtain these figures :—

Power expended in mechanical transmission.....	·209
Power lost in heat.....	·256
Power lost at the points of transformation	·212
Power actually transmitted	·314
Total.....	1·000

I would call the particular attention of electricians to this indication of the precise point where the loss of power which re-

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mains to be studied is produced, a study which will prove of great interest. In every case we shall find in the preceding deductions a second and more precise example of the division of all the losses in the various parts of the transmitting apparatus. The electromotive force of more than 2,000 volts is very high for practical purposes, but it has enabled a power equal to nearly four horse-power to be transmitted to the exact distance predicted, a distance very nearly equal to 8·5 kilometres between the two stations (about 9305·60 yards).

ON SECONDARY BATTERIES.*

BY GEORGE F. BARKER, OF PHILADELPHIA, PA.

[ABSTRACT.]

A secondary battery is one which produces a current in consequence of a previous electrolytic condensation or polarisation upon the surfaces of its plates. Electrolytic polarisation and the production of a secondary current by means of it are almost as old as the voltaic battery itself. In 1801, Gautherot, having used platinum or silver wires as electrodes in a solution of salt, noticed a momentary inverse current when the battery was replaced by a galvanometer. Ritter observed the same phenomenon in 1803 with gold wires. He constructed a secondary battery with pieces of gold separated by cloth discs moistened with salt water. After contact for some seconds with a Volta's pile of more pairs than itself, it produced a current to which Ritter gave the name of secondary current. Platinum, gold, and silver gave a more marked result than copper, brass, iron, or bismuth; and no effect at all was obtained from lead, tin, or zinc. Fifty discs of copper separated by discs of cloth moistened with salt or sal ammoniac solution, when charged with a Volta's pile of 100 pairs, gave a current which decomposed water and produced all the effects of the primary current. Volta himself, as well as Marianini, explained the results by supposing that the decomposition of the salt produced acidic and basic deposits upon the metal discs; a view which Becquerel apparently confirmed by immersing a platinum plate in an acid and another in an alkali and noting that the current was the same in direction as the secondary current. But in 1826 De la Rive obtained the secondary effect from platinum plates immersed in dilute sulphuric acid; and since no basic or acidic deposits were now possible, he regarded the phenomenon as a physical one due to a special or polarised condition of the plates themselves. The current he called a polarisation current. In 1833-4, Faraday's researches on electro-chemical decomposition definitely established the proportionality of the current to the amount of electrolyte decomposed. He observed the "peculiar state" of the plates in his voltameter, and even noticed that when lead acetate was electrolysed, metallic lead was deposited on the negative plate and lead peroxide on the positive; but he offered no explanation of these phenomena. In 1842, Grove, following out an observation of Matteucci, constructed a gas battery in which the current was produced from two plates of platinum immersed in oxygen and hydrogen gases respectively. In 1852, C. W. Siemens used two carbon plates in lead acetate solution as a secondary battery; obtaining, by the action of the current, lead on one of these plates and lead peroxide on the other. One cell of this battery decomposed water; so that the electromotive force of the current must have been nearly two volts.

In 1859, Planté began an elaborate research upon this secondary action, studying carefully the influence of the metal and of the solution employed. The maximum effect was given by lead plates immersed in dilute sulphuric acid; and in 1860, he produced secondary batteries of remarkable power by rolling two sheets of lead together, a strip of insulating material being between them, and placing them in a ten per cent. sulphuric acid. When connected with a battery, the oxygen evolved upon the positive plate attacked it and converted its surface into peroxide; the hydrogen for the most part escaping. When now the current was reversed, the hydrogen reduced this peroxide to finely divided metallic lead and the oxygen attacked the other plate, producing peroxide. By such alternations, the metal may finally be corroded to any depth and the amount of finely divided lead and peroxide indefinitely increased. In Planté's experiments this forming process required three months. In 1881, Faure brought out a secondary battery in which, as in Planté's, lead plates in sulphuric acid were employed. But, in order to avoid the tedious process of "forming," in which the deposits upon the plates were produced by electric action, Faure covered the plates at the outset with a layer of minium or red lead. Upon passing the current, this red lead was reduced to metallic lead on the one plate and oxidised to peroxide on the other, thus producing the battery charged and ready for use in a single operation requiring but a few hours.

* From the *Proceedings* of the American Association for the Advancement of Science, Vol. XXXI., Montreal Meeting, August, 1882.

The theory of the storage of energy by secondary batteries is not difficult. Energy is capacity of doing work and work is force acting through distance. Whenever two attracting bodies are separated work is done upon the system and energy is absorbed by it; and this whether the attraction overcome is mechanical, molecular, or atomic. When an electrolyte is decomposed by an electric current, the current yields energy in proportion to the amount of the ions separated. The quantity of lead peroxide formed in a secondary battery represents the amount of energy stored from the current. So soon, however, as the separating force ceases to act the ions reunite and the stored energy becomes again free. Since the amount of energy thus set free, like that originally stored up, is proportional to the quantity of matter concerned, it is clear that the amount of electricity obtained from a given secondary battery is proportional to the amount of electrolytic products deposited upon its plates. In theory, the electrical energy set free should equal that originally stored up, but in practice this result is never attained.

In its primary expression the chemistry of the secondary battery is simple. In the form made by Grove two platinum plates are placed in acidulated water. Under the action of the current oxygen is set free on one of these and hydrogen on the other,* and the plates are said to be polarised. The electromotive force between these plates is the sum of the contact-potentials involved. Its value is 1·45 volt, and it measures the chemical attraction between oxygen and hydrogen. If now the two plates be connected by a wire the oxygen and the hydrogen recombine, and the energy of combination appears in the form of a secondary current. In general, however, the electrolytic action is accompanied by secondary chemical changes which render the phenomenon much more complicated. In the lead battery, for example, secondary products appear at both electrodes. The oxygen set free at the anode combines with the lead, the final product there being peroxide. The hydrogen evolved at the cathode reduces the oxide which it finds there and produces metallic lead. As before, the electromotive force in the battery is the sum of the contact-potentials, and this, in the case of lead and lead peroxide, is a little above two volts.† When now the plates are connected by a conductor the entire process is reversed. Water is decomposed, and, since the immersed portion of the plates changes sign on discharge, the hydrogen now goes to the peroxide surface and oxygen to the finely-divided metallic lead. The former is deoxidised to monoxide, and the latter oxidised to the same condition. Simultaneously a current flows through the conductor, the electromotive force of which is two volts, the strength of which is the ratio of this electromotive force to the resistances in circuit, and the duration of which depends upon the amount of secondary products deposited upon the plates during the charging. Beside this, however, another action takes place in the secondary battery which is of great importance. The sulphuric acid in which the plates are immersed attacks both the peroxide on the one plate and the metallic lead on the other, and converts both into lead sulphate. Moreover, as fast as the monoxide is produced by the discharge of the battery it is also converted into sulphate, so that upon complete discharge the plates are precisely alike, both being covered with lead sulphate.

The secondary batteries employed for experiment were those of Planté and Faure. Of the former type two cells of the larger size made by Breguet were used. Of the latter one cell of medium size made by Reynier and 34 cells of the size exhibited at the Electrical Exhibition at Paris were experimented with. The battery of 34 cells was made in January under my direction.‡ Each cell consisted of six plates each 20 by 60 centimetres, the lead being a millimetre thick. The exposed surface of each plate was, therefore, was nearly 0·25 of a square metre, and of each cell about 1·50 square metres. For the whole battery the surface was about 50 square metres (exactly 48·96). Each plate was covered on both sides with a coating of red lead about a millimetre thick made into a paste with water. Parchment paper was then folded over the whole, and over this a covering of felt sewed together at the edges. The plates were then folded transversely, and each pair intercalated. Heavy lead terminals were attached to each plate, and three pairs of plates were placed in each box, the terminals of one plate of each pair being united together and furnished with a connector. The boxes were lead-lined, and measured 31cm. in length, 25 in depth, and 11 in width. One of the two sets of plates was in contact with the lead lining, the other was insulated. The latter was always

* Undoubtedly the oxygen is produced by a secondary reaction.

† Planté observes that after complete charging the electromotive force may rise above two volts at the instant of removing the battery; but as it falls to this value at once on closing the circuit, and remains so, he attributes the first result to the temporary production of a peroxidised substance, as hydrogen peroxide or persulphuric acid, at the anode.

‡ This battery, as well as the cut-out, Fig. 1, was made by Jas. W. Queen and Co., of Philadelphia.

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made the positive end. The total weight of a single cell was 17 kilograms.*

The charging current was generated by a Gramme machine whose field was maintained by an auxiliary dynamo. The maximum obtainable electromotive force of this current was 85 volts. In general, however, a much less electromotive force was used, sufficient only to give a current of from 10 to 20 amperes through the thirty-four cells arranged in series. Currents as high as 45 amperes, however, were occasionally employed. At the outset, considerable difficulty was experienced from the discharge of the battery when from any accidental cause the current fell below the potential of the thirty-four cells. The wear of the brushes of the auxiliary dynamo sometimes opened its circuit and thus destroyed the magnetic field of the Gramme. There being now no counter electromotive force to oppose it, the secondary battery current flowed back through the machine, discharging the battery completely. A simple device was arranged to prevent loss of the charge in this way should the charging current become weakened. This device is represented in Fig. 1, where A

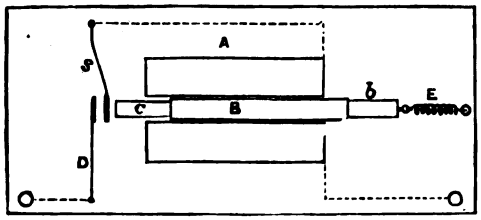

FIG. 1.

is a coil of No. 10 copper wire. Within its core is a rod of iron B, prolonged at both ends by brass rods of smaller diameter, *b* and *c*, these being supported upon rollers. Opposite the end of one of these rods is a flat spring S, faced with platinum and making contact when depressed with a similar brass strip D, also faced with platinum. The course of the current is shown by the dotted lines. When the circuit is closed between S and D, the current traversing the coil draws the iron bar strongly into its, axis, and the end of the brass rod pressing against S holds the circuit closed. Should the current weaken, the spring S reacts against the rod pushing it back and opening the circuit. By means of an auxiliary spiral spring, E, the instrument may be adjusted to any required current-strength. It would seem that by no possibility can the accumulated charge in the battery be lost, when this automatic cut-out is in circuit. As now described, the coil is of large wire, and the entire current passes through it.

(TO BE CONTINUED.)

IMPROVEMENTS IN DISTRIBUTING AND MEASURING ELECTRICITY, &c.

(CONCLUDED FROM PAGE 479.)

"In order to combine the advantages of comparatively high potential in the feeding conductors with lower potential in the houses in which the electricity is used a system of three conductors is used in combination with two dynamo machines coupled in series. This system is shown diagrammatically in Fig. 3, where A B represents the two dynamos, C D and E F represent the extreme conductors, which I will call the positive and negative conductors, and G H represents the intermediate conductor. The positive pole of the dynamo machine A is connected to the conductor C D, and its negative pole to the conductor G H. On the other hand, the positive pole of the dynamo machine B is connected to the conductor G H and its negative pole to the conductor E F. The houses to be supplied are divided into two approximately equal parts, preferably the houses being taken alternately. The houses of one part are supplied between the conductor C D and the conductor G H, and those of the other part between the conductor G H and the conductor E F. The intermediate conductor G H may be of much smaller dimensions than either of the other two, as it has only to carry the difference of current consumed by the two divisions of consumers, that is those connected with the conductor C D and those connected with the conductor E F. It need not be insulated, and, indeed, it may be replaced by the iron or other metallic covering often used to protect the copper conductors. In cases where the two divisions of consumers may be safely assumed to have a very approximately equal consumption at all times the intermediate conductor G H may be replaced in part by the earth, and the negative pole of the dynamo machine A and the positive pole of the dynamo machine B be connected together and to the earth."

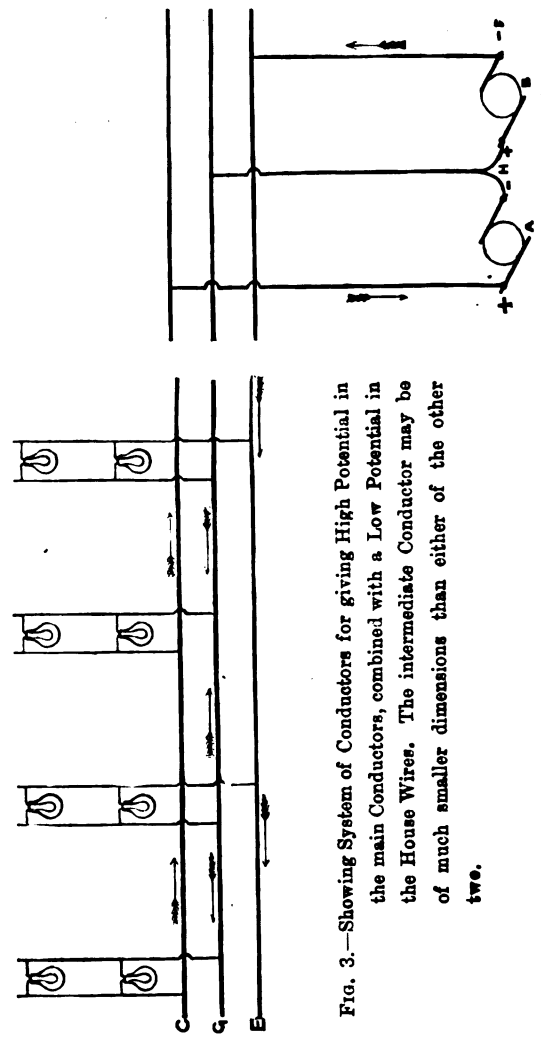

FIG. 3.—Showing System of Conductors for giving High Potential in the main Conductors, combined with a Low Potential in the House Wires. The intermediate Conductor may be of much smaller dimensions than either of the other two.

With regard to (2) measurement the apparatus described is an improvement upon previously designed apparatus. "In Fig. 4 the piece A is

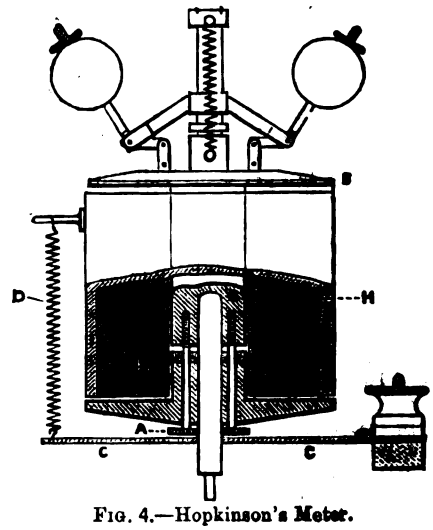

FIG. 4.—Hopkinson's Meter.

* Mr. W. Lachlan, the electrical engineer of the Light and Force Company, of New York, has kindly furnished me the following figures concerning the Faure batteries of improved construction recently imported in the steamer "Labrador." Four types of Faure batteries are made in Paris, called A, B, C, and D. Type A consists of seven positive plates, each 37 × 23·5cm. and 3mm. thick, perforated with holes 6mm. in diameter 10mm. apart, alternated with seven negative plates of the same size, but only 0·55mm. thick, and similarly perforated. The seven positive plates weigh 16·66 kilograms, the seven negative ones 2·77 kilograms. The rod lead spread on their surfaces weighs 22·13 kilograms, the two exterior plates being covered only on their interior surfaces, so that there are 26 active surfaces in all. Each plate has an electrode 7cm. wide. The box is 45 × 20 × 40cm. in size, is pitched throughout, and weighs with its cover 10 kilograms. The battery complete ready for charging weighs 63 kilograms. In type C there are five positive plates each 24 × 19cm., 3mm. thick, and four negative plates 0·5mm. thick, both perforated with holes 5mm. in diameter and a centimetre apart. The positive plates weigh 7·14 kilos., the negative 0·888 kilos. Sixteen surfaces are covered with red lead weighing 8·28 kilos. The electrodes are 3·5cm. wide. The box weighs 3 kilos., and the battery complete 20·37 kilos. Each cell of type A contains, it is claimed, when fully charged, 375 ampere-hours of current delivered at an electromotive force of 2 volts. Hence it will furnish, for example, a current of 25 amperes for 15 hours. Type C contains 150 ampere hours. Types B and D are round cells in jars of earthenware. The former weighs 35 kilos., and contains 225 ampere-hours; the latter 8 kilos, and contains 75.

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carried by and revolves with that part B of the core of the electro-magnet H which is suspended from the governor, and it makes contact with the bar C, which is insulated and does not revolve. Thus there is always a rubbing when contact is made, which serves to keep the two surfaces clean. The insulated bar C is held up by the spring D. The other parts of the meter are similar to and act as described in Patent Specification No. 49, of the year 1882. When more than one dynamo machine supplies electricity to a system of distributing mains there is some difficulty in removing a machine from the circuit without a destructive electric arc being formed when the circuit is broken. This inconvenience is remedied by introducing into the conductor from the dynamo machine an instrument such as is shown in Fig. 5. A A is an electro-magnet in the circuit of the dynamo machine, its armature B carrying a piece C, making connection between D and E in the circuit. The connection between D and E is maintained so long as a certain current passes in the circuit, but when the current diminishes to a point below this limit the armature B and piece C drop, and the contact between D and E breaks. If it be desired to break the circuit of one of the dynamo machines it is only necessary to stop such

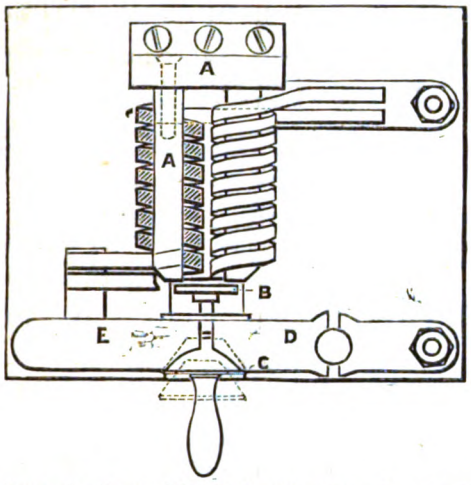

FIG. 5.—Apparatus for avoiding destructive Arcs when one Dynamo is removed from a Circuit in which are other Machines.

machine, and as its speed diminishes, at the right moment its automatic switch piece drops and the connection ceases. The form of the switch may, of course, be varied."

DIRECT SPANISH TELEGRAPH COMPANY (LIMITED).

The nineteenth ordinary general meeting of this Company was held at the offices, Leadenhall-buildings, Leadenhall-street, on the 31st ult., under the presidency of Mr. Edmund Etlinger (in the absence abroad of the chairman of the Company, Mr. Neil Bannatyne).

The MANAGER (Mr. Ch. Gerhardi) read the notice convening the meeting.

The CHAIRMAN said: I now suggest that the report and accounts should be taken as read. I propose to go *seriatim* through the various items, and to comment on them. The first paragraph states, "The annexed accounts for the half year ended 31st December, 1882, show a balance to the credit of profit and loss of £7,056 17s. 9d." This result, I need hardly tell shareholders who have been connected with the Company for some time, is very satisfactory. It represents, after paying the Preference dividend of 10 per cent., a distribution equal to 6 per cent. on the Ordinary stock, and consequently, if we had had no mishaps, we should probably have been able to recommend dividends of 10 per cent. on the Preference shares, and of 5 per cent. on the Ordinary shares, and to carry forward £1,000 to the reserve fund. We may, therefore, conclude that the half year was very satisfactory as far as traffics and profits are concerned. In the June half year the profit was only £5,889, and consequently the second half of the year to December was better than the first half year by £1,167. In the second paragraph of the report it is stated, "The receipts, although somewhat inferior to those of the last half year, are in excess of those for the corresponding period of 1881." In the June half of last year the receipts from telegrams were £11,300 against £10,841 in the past half year, and, consequently, there was an increase in the former period of some £500; but in spite of that, as I have said, the last six months' profit was better than that of the June half year. This is accounted for by reason of the repairs of the June half year having been heavy compared with the repairs of the December half year. That accounts for the fact that the profit is a good deal better, though the actual receipts from the transmission of messages were a trifle less. The traffic since the 1st January this year has been on the whole very satisfactory. For the month of January it was £1,658, for February it amounted to £1,459, and for March the receipts were £1,772, estimating those for to-day. For the three months, therefore, including the short month of February, the traffic amounted to £4,889. Last year, in the same period, we took £5,428, but then during the present quarter the Bilbao cable has been open only twenty-eight days. Owing to our joint purse arrangement we have received our income, though the cable was interrupted, but though a joint purse arrangement exists you do not, as a matter of fact, get your full proportion of the traffic. Many people, instead of going to the Eastern Company, go to the French cable in Paris, and many if they cannot telegraph direct will not telegraph at all. That accounts for our loss of traffic, though we have a joint purse arrangement; but with no such arrangement our traffic would have been very poor indeed. While on the subject of traffic I may point out that we have made considerable alterations since we last met. We met at Cannon-street last time, but we determined to come to this part of the town, as we knew that the greater part of the Spanish traffic came from this neighbourhood, and our idea, which has proved correct, was to attract traffic by coming here. We used to employ the Post Office for carrying our messages from London to Falmouth; but we have now contracted with the Post Office for a special wire going from this building to Falmouth, and it is there connected with our cable. From our office down stairs you can now telegraph direct to Madrid. This is an enormous improvement, and it has attracted a considerable increase of traffic. We have also a pneumatic tube by which all messages are whistled through from here to St. Martin's-le-Grand, and from there to here. We have, therefore, hired a wire and a tube. Before we entered into this arrangement we made elaborate calculations. We knew that we had to pay on every message we sent from here to Spain 1s., and also 1s. for every message that came on our cable in Spain for its transmission from Falmouth to London. These two items came to £2,400 a year. The whole of that we save. The hire of a special wire to Falmouth, the hire of a tube, and the extra rent we pay for this office and downstairs do not come to quite so much. There is, therefore, no loss on the arrangement, and we are located in the middle of the Spanish traffic. I think this arrangement has worked very satisfactorily, and that, in the long run, we must gain considerably from it. The report then says: "The Barcelona cable was broken down from the 8th to the 31st December. It was satisfactorily and economically repaired, and has since been in excellent working order. The cost of these repairs, £751 9s. 5d., was paid out of the revenue of the half-year." It is hardly a fact to say that a break is at any time a matter of congratulation, but, considering that this cable has been down nine years, and never cost us one farthing, I think we are very well satisfied in having a fault such as to cost us only £751. The fault was not at sea, but close in shore, and the cable had been eaten into. The cost of the repair was, however, very small, but the reason for that was that we received every assistance from the French Government, which enabled us to do the repair without sending out a ship from here. Had we sent out a ship the repair would have cost us about three times as much. This break made a little alteration in the traffic for January, but in February the traffic recovered itself, and for February and March the traffic was quite as good as before. The next paragraph in our report deals with the joint purse arrangement we made with the Eastern Telegraph Company. I think the circular we sent to all the shareholders informed them of the fact last year. It came into operation on the 1st of December, and we think it is an arrangement fair to both parties, and will work, as it has so far worked, very satisfactorily. I do not say that because our cable broke down, and we have received an income from the Eastern Company, but because we both save expense by not competing for the traffic, and employing agents. All that is saved, and each party receives its proportion of the traffic. At present the arrangement has worked more favourably for us, as our cable broke down, but to-morrow they may break down, and we should then have to work for them. As to the distribution of £7,056 profit, this is a subject on which I must speak with regret. We say in the report—"After paying the dividend on the Preference shares, amounting to £2,921 10s., and appropriating £200 to the reduction of the preliminary expenses account, there remains a balance of £3,935 17s. 9d. The directors deeply regret that they cannot recommend the payment of a dividend on the Ordinary shares, feeling the necessity of carrying the whole of this balance to the reserve fund, owing to the unfortunate interruptions of the Bilbao cable since the 1st January last, the repairs of which have to be provided for." Now, gentlemen, what has taken place since the 1st January has been a combination of misfortunes for us. In December last we discovered a small fault in the Lizard, close to the shore end; but that was nothing. The cable there is very much exposed to the sea. On the 14th of January, however, a break or fault was unfortunately found to exist in eighty fathoms of water, at about 145 miles from Bilbao, and at the same time another fault occurred 175 miles from Bilbao. We sent out a ship, which repaired first the break at the Lizard, and next the two other faults I have mentioned—at 145 and 175 miles from Bilbao. The ship had come back, but on the 9th March the cable again became interrupted. This time it was at twenty-two miles from Bilbao. The ship went out to repair that, and while she was out another fault developed itself about 140 miles from Bilbao; and the ship is out, having repaired the fault twenty-two miles from Bilbao, engaged on the repair of the fault 140 miles from Bilbao. The cost of these repairs we cannot quite tell, but as far as we can estimate them, they will not be less than £8,500. They may come to more, but I do not think we can expect them to be less. We have a reserve fund of £6,000. After paying our Preference dividend, and writing £200 off preliminary expenses, we have left £3,935 out of the profit of the last half year. We propose transferring that to the reserve fund, which will give us £9,935 to meet the cost of repairs. If we can do them for £8,500, we shall then have left £1,430, a very small amount—in fact, an almost inadequate amount—to reserve for contingencies. The directors, therefore, came to the conclusion to recommend you to forego a dividend for the present, trusting that the repairs will not occur so often on another occasion. It is quite possible that the present unfortunate breaks are an accidental combination of misfortunes at one and the same time, which may not occur again for a long period, but we ought not to shut our eyes to the fact that these repeated breaks indicate a mechanical deterioration of the cable. I do not think I have any further observations to make on the report, and as regards the balance-sheet I do not think there is much to observe. We have placed £395 and £221 in suspense. These items represent the expenditure we have incurred in removing from the other offices here, and in fitting up the special wire. It would not be fair to saddle those expenses upon one half year, and we therefore propose to wipe those amounts off gradually. In the profit and loss account you find that our expenses have slightly increased—by about £380. These items are accounted for chiefly by a small increase in salaries. On the whole, I may say, as to the expenses, that we have spent 28 per cent. of our gross receipts in working the Company, and in comparing that with the working expenses of any other company—except Atlantic companies, owing to the great lengths of their cables—it will be found that our expenses are quite reasonable. I now move that the report and accounts be received and adopted.

Mr. ABRAHAM SCOTT seconded the motion, which was carried unanimously.

The CHAIRMAN then moved the payment of a dividend at the rate of 10 per cent. on the Preference shares.

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Mr. SCOTT seconded the resolution, and it was carried unanimously.

On the motion of Mr. DYETT, seconded by Mr. COCHRAN, the retiring directors, Messrs. Etlinger and Scott were re-elected; as was also the auditor, Mr. Herbert R. Duke.

The CHAIRMAN then expressed a hope that when the engineer returned home with the ship he would give a tolerably good account of the cable. If necessary, the directors would let the shareholders know how things were going on.

Mr. BRAMLEY then moved, and Mr. LOW seconded, a vote of thanks to the chairman and directors, which was carried.

The CHAIRMAN, in acknowledging the vote, stated that the directors had been connected with the undertaking from the very beginning. They took a great interest in it, and their joint holdings were very considerable. Naturally, therefore, they did all they could to keep down the expenditure.

The proceedings then terminated.

ELECTRICAL POWER STORAGE COMPANY (LIMITED).

An extraordinary general meeting of the shareholders was held at the offices of the Company, 4, Great Winchester-street, on Thursday, Sir Daniel Cooper, Bart., K.C.M.G., in the chair.

The SECRETARY (Mr. Holland Dell) read the notice convening the meeting, and the minutes of the preceding meeting, which were confirmed.

The CHAIRMAN said: This meeting has been convened to submit for confirmation the resolutions passed at the meeting of the Company held on the 21st March. I will put them in the shape of two resolutions, as the last alteration should be put specially by itself.

The resolutions, the effect of which has been published in *The Electrician*, were then separately confirmed unanimously.

The CHAIRMAN: It is not usual at these confirmatory meetings to give any information; but if I had to give any information it would be favourable. The business of the Company is going on all right, and I hope we shall have a good story to tell you when we next call you together.

The meeting then closed.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY.

The ordinary general meeting of this Company was held on Thursday, at the offices, Tokenhouse-buildings, Moorgate-street, and the report which was presented to the meeting for the year ending December 31st last stated that "the Company's percentage of the gross earnings of the Western and Brazilian Company amounts for the year to £2,769 18s. 3d., the December quarter being estimated at £745. After setting aside £500 for redemption of debentures, and providing for all charges and debenture interest accruing during the year, there remains a net balance of £940 16s. 7d., out of which it is proposed to pay a dividend of two shillings per share (£1 per cent.) and carry forward a balance of £109 8s. 7d. to next account."

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES APRIL 4.		BUSINESS DONE WEEK ENDING APRIL 4. Highest.		Lowest.
Anglo American	£1⅛,	52⅛	52⅜		51
Do. Preferred	83⅛,	84⅛	84⅜		83⅛
Do. Deferred	21,	21⅛	21⅜		20⅜
Brazil Submarine	12⅜,	12⅝	12 9-16		12⅜
Cuba	10,	10⅛	10⅛		10⅛
Do. Preference	17,	18	—		—
Direct Spanish	5⅛,	5⅜	5⅛		5
Do. Preference	15⅛,	16⅛	16⅛		16⅛
Direct United States Cable	12⅜,	13	12⅜		12 9-16
Eastern Telegraph	10⅜,	11⅛	11		10⅜
Do. 6 per Cent. Preference	13,	13⅛	13⅜		13⅜
Do. 5 per Cent. Debentures, 1899	104,	107	—		—
Eastern Extension	11⅛,	11⅜	11 13-16		11 11-16
German Union	10,	10⅛	10⅛		10⅛
Globe Telegraph and Trust Company	6⅛,	7⅛	7 1-16		6⅜
Do. Preference	12⅜,	13⅜	13		12⅜
Great Northern	12⅛,	12⅜	—		—
Indo-European	32⅛,	33⅛	—		—
Mediterranean Extension	1⅛,	2	1⅜		1⅜
Do. Preference	6,	7	6⅛		6⅛
Reuter's	10,	10⅛	—		—
Submarine	247,	252	£51		2£0
West India and Panama	1⅛,	1⅛	1⅜		1⅜
Do. 1st Preference	7⅛,	8	7⅜		7⅜
Western Brazilian	7⅛,	7⅜	8		7 9-16
West. Union 7 per Cent. 1st Mortgage	125,	128	—		—
Do. 6 per Cent. Sterling Bonds	102,	105	—		—

TELEPHONES.

Consol. Telephone and Maintenance	⅜,	1⅛	1 1-16		1
Oriental	⅛,	⅜	⅛		⅛
United Telephone	10⅛,	11	10⅜		10⅛

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	6⅜,	7⅛	7⅛		6⅞
Do. (fully paid)	9,	10	9⅛		9⅛
Hammond Light	3⅜,	4⅛	3⅜		3 11-16
Eastern Electric (fully paid)	—,	—	—		—
Pilsen, Joel, and General Electric	⅛,	1	—		—
Swan	1⅛,	2⅛	2		2
Maxim-Weston	⅛,	⅛	5-16		5-16

TRAFFIC RECEIPTS FOR MARCH, 1883.

COMPANIES.	Mar., 1883.	Mar., 1882.	Increase.	Decrs.
Cuba Submarine Company	4,500	4,123	377	—
Direct Spanish Telegraph Company	1,770	2,332	—	562
Great Northern Telegraph Company	20,480	—	—	—
Eastern Telegraph Company	49,529	48,824	705	—
Eastern Extension Telegraph Company	32,970	33,677	—	707

SUBMARINE CABLES TRUST.—Notice is hereby given that the COUPONS of the SUBMARINE CABLES TRUST, due on the 15th instant, will be PAID on and after MONDAY, the 16th instant, by Messrs. GLYN, MILLS, and CO., of 67, LOMBARD-STREET, between the hours of 10 a.m. and 2 p.m.

The Coupons must be left for examination three days previous to calling for payment.

LEWIS WELLS, Secretary.

66, Old Broad-street, E.C., April 2, 1883.

CITY and GUILDS of LONDON INSTITUTE for the ADVANCEMENT of TECHNICAL EDUCATION.

TECHNOLOGICAL EXAMINATIONS, 1883.

Examinations in Technology will take place at the different provincial centres throughout the kingdom on WEDNESDAY EVENING, May 30th, 1883, at 7 o'clock.

Secretaries are informed that the latest date for sending in returns of Candidates who wish to be examined in May next is SATURDAY, April 28th, after which date no application can possibly be received.

Individual Candidates who are unable to arrange to be examined at a provincial science centre can, on application to the Director and Secretary, be examined in London at the Finsbury Technical College, Tabernacle-row, E.C.

The examinations will be held in 42 subjects. A Programme, containing Syllabus of each subject and last year's examination questions, can be obtained from the Central Office of the Institute, Gresham College, London, E.C.

PHILIP MAGNUS, Director and Secretary.

MOST IMPORTANT SALE BY TENDER.

IN THE MATTER OF
THE DUBLIN ELECTRIC LIGHT COMPANY (Limited),
IN LIQUIDATION.

TO BE SOLD:

LOT No. 1.—The PREMISES situate at GREAT BRUNSWICK STREET, in the City of Dublin, lately known as "Farrell's Horse Repository." This is one of the most central positions in the city. The premises are held by the above Company under leases for a long term of years unexpired, subject to the almost nominal rent of £110 per annum. A portion of the premises has been taken by the Corporation of Dublin; £1,881 is to be paid by them therefor, and the purchaser will be entitled to this amount.

LOT No. 2 (AS A GOING CONCERN).—The INTEREST and GOODWILL of the Company in the Premises situate at Liffey-street and Fade-street, with the PLANT, MACHINERY, FIXTURES, FITTINGS, and LICENCE to use the "BRUSH" MACHINES and APPLIANCES.

This Company has been for the last 18 months supplying Electric Light in the City of Dublin, and the business is, at present, in full working order. Having regard to the extensive orders which the Company was called upon to execute, and to the growing desire to avail of the advantages of the Electric Light, there is a large field for successful enterprise open to any one possessing sufficient capital to supply the requirements of the public.

Sealed Tenders for the Two Lots, or for each Lot separately, will be received by the Liquidator, Mr. ROBERT GARDNER, up to 12 o'clock on SATURDAY, the 14th day of April next, at which hour they will be opened by him in the presence of the parties attending, and the Purchaser declared.

For Statement of Title, Conditions of Sale, and any further information, apply to

Messrs. CASEY and CLAY, Solicitors,
21, St. Andrew-street, Dublin; or to
ROBERT GARDNER, Liquidator,
Trinity Chambers,
40 and 41, Dame-street, Dublin.

March 28th, 1883.

FAURE-SELLON-VOLCKMAR ACCUMULATORS.

On and after 1st January, 1883,
THE
ELECTRICAL POWER STORAGE COMPANY
(Limited),
4, Great Winchester-street Buildings, E.C.,
will be prepared to supply
FAURE-SELLON-VOLCKMAR ACCUMULATORS.

Which can be used in conjunction with any Incandescent Lamp or Electrical system, and afford the only reliable and economical means of lighting Private Houses, Hotels, Theatres, Ships, Railway Carriages, &c., by Electricity.

Particulars and prices post free on application.

A YOUNG GENTLEMAN, with a thorough knowledge of the Brush system of Electric Lighting, desires an ENGAGEMENT as ELECTRICAL ENGINEER.—Address, J. H., "ELECTRICIAN" Office, 386, Strand, London.

ELECTRICIAN and MANAGER.

WANTED, by an Electric Light Company, a competent ELECTRICIAN and GENERAL MANAGER. He must be willing to canvass for customers, and to assist generally in promoting the business, and must be fully competent to undertake the management of the installation in all respects. Salary, £200 a year. Address, by letter, stating age, references, and qualifications, on or before the 11th April, to SECRETARY, Hastings and St. Leonards Electric Light Company, 62, Cambridge-road, Hastings.

FACTORY and WATERSIDE PREMISES to be LET, or the LEASE at £200 per annum rent to be SOLD. First class premises, with a frontage of about 40 feet to the canal, and 40 feet on the other side to the road. Depth about 90 feet, ground floor of factory, with two floors above 18 feet by 85 feet. Steam power on the premises, to be taken at a valuation. Situate close to King's-cross. Apply to the SECRETARY of the London General Cab Company, 68, York-road, King's-cross, N.

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SLIP

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending April 6 were £3,521.

SOLENOID.—It may be news to some of our younger readers to know that our word solenoid is derived from the Greek σωλην, a tube.

CHARING-CROSS ELECTRIC RAILWAY.—The Charing-cross and Waterloo Electric Railway Bill was read a second time in the House of Commons on Monday last.

THE BRUSH SYSTEM IN ABERDEEN.—The experimental lighting of certain streets in Aberdeen by the Brush system, which has continued for three months past, is to be extended over another four weeks.

INSTITUTION OF MECHANICAL ENGINEERS.—At the ordinary general meeting of this institution, held on Wednesday and Thursday last, a paper, by Mr. A. C. Bagot, on "The Application of Electricity to Coal Mines," was to have been read.

THE TELEPHONE IN HOLLAND.—The Bell Telephone Company, established in Holland in December, 1880, has, at the present time, 915 subscribers; in Rotterdam, where the company started on the 1st March, 1882, there are already 378 subscribers.

KING'S COLLEGE, LONDON.—We understand that Professor W. Grylls Adams, F.R.S., will continue his course of lectures on electricity (voltaic and dynamic) and magnetism during the ensuing term. Further information can be had of the secretary, Mr. J. W. Cunningham.

THE GENERAL TELEGRAPHIC NEWS COMPANY.—An extraordinary general meeting of this company is to be held at 17, Cornhill, on the 3rd May, at 2 p.m., to receive an account of the winding up of its affairs, and the disposal of its property from the liquidator, Mr. W. King.

THE QUESTION OF THE WIRES.—The Marylebone Vestry have resolved to send a deputation to wait on the Government with reference to the liability of local authorities for the safety of over-head wires, and as to whether they have the power to stop the erection of such wires.

NEW COMPANY.—The American Postal Telegraph Company was incorporated at Albany, New York, on the 28th March. It is formed for the purpose of buying, constructing, owning, using, and maintaining telegraph lines throughout the State of New York. The capital is 5,000,000dols.

THE POST OFFICE RIFLES.—At a full dress parade of the 24th Middlesex (Post Office) Rifles, held at St. George's Barracks, Trafalgar-square, W.C., on Wednesday morning, Major General Higginson, C.B., distributed the Khedive's Bronze Star to those members of the corps who took part in the Egyptian campaign.

DIRECT UNITED STATES CABLE COMPANY.—This company notify that the half-yearly interest on their Six per Cent. Debenture Loan will be paid on and after the 16th inst. at the Consolidated Bank, Threadneedle-street, E.C., where coupons should be left for examination three clear days before applying for payment.

THE SOUTH AFRICAN CABLE.—The Eastern Telegraph Company notified the interruption of the Eastern and South African Telegraph Company's cable between Zanzibar and Mozambique on the morning of the 6th inst. The company's repairing ship stationed at Zanzibar was to proceed as quickly as possible to restore telegraphic communication.

ANGLO-AMERICAN TELEGRAPH COMPANY.—The directors of this company have resolved, after placing the quarterly sum of £37,500 to the credit of the Renewal Fund, to declare an interim dividend for the quarter ending March 31, 1883, of 15s. per cent. on the Ordinary and 30s. per cent. on the Preferred stocks, both free of income-tax, payable on the 1st of May.

SOCIETY OF ARTS.—The following are the dates and arrangements for the forthcoming meetings of the Society of Arts:—Ordinary meetings, Wednesdays—April 18, "The Government Patent Bill," by H. Trueman Wood, B.A., Secretary of the Society. Applied Chemistry and Physics Section, Thursday—May 24, "The Development of Electric Lighting," by J. E. H. Gordon, B.A.

SIXPENNY TELEGRAMS.—It is rumoured that great efforts will be made during this year to increase and extend the wire accommodation of the Postal Telegraph Service, in view of the anticipated reduction of rates. Something like a quarter of a million, it is expected, will be required for this purpose. The construction staff of the engineering branch are expecting to be deprived of their annual leave this year.

PERSONAL.—It is stated that Her Majesty has signified her intention of conferring the honour of knighthood on Mr. Richard Henry Wyatt, for twenty-five years parliamentary agent to the Treasury. Amongst the important acts which Mr. Wyatt has helped to carry through Parliament was that relating to the telegraphs; for his services in regard to this matter, Mr. Wyatt received the thanks of the Postal Department.

LOUIS MAICHE.—In its issue for the 7th inst. our contemporary, *L'Electricité*, gives a biographical notice, with a portrait, of this well-known electrician. It appears that he was born at Mans on the 22nd June, 1843, and is, therefore, not forty years old yet. Our contemporary gives a list of M. Maiche's inventions, amongst which are batteries, electrophones, and other electrical apparatus and applications of electricity.

THE FRENCH ACADEMY OF SCIENCES.—The Academy have postponed the award of the Boidin prize, consisting of a gold medal and 3,000 francs, until 1885, on the ground that the essays did not conform to the conditions laid down. Seven essays were sent in, and one, "On the History of Storms," was awarded 1,000 francs for merit. The subject set was "The Origin of Atmospheric Electricity and the Development of Electrical Phenomena in Storm Masses."

"ANNALES DE L'ELECTRICITE."—It may be interesting to our friends to know that, as a rule, more than 50 per cent. of the matter contained in this publication is taken *without acknowledgment* from our pages. Perhaps literary honesty will go still further, and we shall in a few weeks have to notice that some friendly hand simply reproduces our pages entirely, and without acknowledgment. Five consecutive pages, including our last special supplement, will be found in the issue for March 31. After this our American friends must stand in the background.

THE UNITED TELEPHONE COMPANY.—The officers and *employés* of this company on Tuesday last presented to their chairman, Mr. James Brand, through their managing director, Mr. Joseph B. Morgan, a handsomely-illuminated address. The address stated that it was felt that the rise, progress, and development of the United Telephone Company were mainly owing to the indomitable energy, pluck, and manliness which had been shown by the chairman, coupled with an honesty of

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purpose that had confounded the enemies and increased the friends of this novel undertaking.

THE CZAR'S CORONATION.—*The Times'* St. Petersburg correspondent, telegraphing on Tuesday last, says:—"The work of preparation at Moscow goes on apace. The walls and towers of the Kremlin are to be illuminated throughout with various coloured lamps, while the towers of the Assumption and of John the Great are to be outlined with 3,500 Edison lights, and four electric suns, of the power of 40,000 candles each, are being placed on the four turrets on the outer walls. The Moscow palaces and the house of the Minister of War are being connected by telephone."

PREVENTION OF COLLISIONS AT SEA.—The Council of the Society of Arts have appointed a committee to consider the question of preventing collisions at sea. The work of the committee will be confined to a consideration of the best means of preventing collisions in fogs. The committee will be glad to receive any information on this subject from persons who have given their attention to it, or to consider any proposals having for their object the prevention of such collisions. All such communications should be addressed to the Secretary of the Society of Arts, John-street, Adelphi.

INDO-EUROPEAN TELEGRAPH COMPANY.—The directors of this company have determined, after setting aside £5,000 to the reserve fund, providing for freeholds and stores, £8,301 on maintenance account, and for a payment to the India Office of £6,500 on account of the Persian Debt in the nature of a reserve fund, to recommend the payment for the six months ending the 31st December, 1882, of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year and a bonus of 15s. per share, carrying forward £1,900 to the next account.

DISPLAY OF AURORA.—The following account of a display of aurora, which was witnessed at Kirkwall on the night of Tuesday week (April 3), is taken from an Edinburgh paper:—"Shortly after nine o'clock the sky in the north, east, and west assumed a light yellowish colour. Streamers began to rise, rather faintly first, but afterwards they would ascend from the horizon and meet in the zenith, diffusing most beautiful colours. About half-past eleven o'clock clouds in the north appeared to change to an inky colour. Streamers now changed to flashes, going with the rapidity of lightning, the effect being most beautiful. The display of aurora has been very common in Orkney this season."

THE EDISON SYSTEM IN AMERICA.—Recent advices from the United States state that an Edison Electric Illuminating Company has been formed in Boston, Massachusetts, with a capital of 1,000,000dols., and that a central station was to be established at once capable of supplying 20,000 lights. Another company with a similar title has also been organised in Danville, Pennsylvania, where also arrangements are being made to start a station. The Western Edison Company of Chicago are stated to have secured a contract for putting their lamps into the Merchants' National Bank in that city, and are also putting down isolated plant in Haverley's Theatre and the American Express Building there.

INTERNATIONAL ELECTRIC EXHIBITION, VIENNA.—We learn that in consequence of the intervention of the Austro-Hungarian Embassy at St. Petersburg, and a report from the Russian Minister of Finance, the Emperor of Russia has granted the Imperial Russian Technical Society of St. Petersburg the sum of 15,000 roubles, to aid in the formation of a Russian section at the International Electric Exhibition at Vienna. At a meeting held on 19th March (old style), the president of the above-mentioned society, Prince Kotschubey, informed the members of this imperial resolution, and the chairman of the electrical section, Mr. Welitschko, who represented the Russian Government at the Paris Exhibition in 1881, has been entrusted with the organisation of the Russian exhibits.

AN EXTRAORDINARY RUN.—We are informed that an extraordinary run was recently made by an engine attached to one of the steam dynamos in the Edison Central Station, Pearl-street, New York, which ran for seventeen days and nights successively with a load varying from a minimum of 40 horse-power to a maximum of 150 horse-power indicated. The engine which accomplished this feat is a "Lawrence" direct acting high speed engine running at 350 revolutions per minute, made by Messrs. Armington and Sims, of Providence, R.I. If we suppose the engine to have had a five-feet driving wheel attached, this performance would have been equivalent to that of a locomotive making the circuit of the globe at the equator. It should be added that the bearings of the engine when stopped were not found to be unduly heated.

TELEGRAPH CLERKS AT DUBLIN.—In the House of Commons on Monday night, Mr. O'Donnell asked the Postmaster-General if he had received a petition from clerks in the Postal Telegraph Department, Dublin, asking for an annual holiday equal to the annual holiday enjoyed by postal telegraph clerks in London; and what reply he had given to the petition. Mr. Fawcett replied that two years ago an application was received from the telegraph force in Dublin requesting that those of their number who were in receipt of £2 a week and upwards might be granted one month's leave in the course of the year, and in May last it was announced to the service generally that no extension of the annual leave could be granted. Since then no application on the subject had reached him from Dublin. He added that in Dublin the period of annual leave is practically the same as in London—viz., for superintending officers, one month; for telegraphists who have Sunday and night duty, three weeks; and for others, one fortnight.

TATE'S ELECTRICAL ENGINE STOPPER.—At a recent meeting of the Royal Scottish Society of Arts, at Edinburgh, the report of a committee which was appointed some time since to examine and report upon Tate's electric valve-closing apparatus was submitted. The report stated that this invention seemed admirably adapted for the purpose specially in view—viz., the immediate stoppage of machinery in the event of an accident, either to the machinery itself or to persons employed. The value and importance of an arrangement, the report proceeded, by which the actuating power in large mills could be rapidly controlled and brought to a stand, could not, in the opinion of the committee, be overestimated. The facility with which this could be accomplished from any part of the factory, however distant from the engine, by the easy and instant application of electricity in the mode proposed by Mr. Tate, appeared to them to merit the highest commendation of the society. This apparatus was described and illustrated in our issue for October 24, 1882, p. 535 of Vol. IX.

TELEGRAPH WIRES STRUCK BY LIGHTNING.—We have received the following account of the destruction of a considerable length of telegraph wire during a thunderstorm which occurred in Cyprus on the 1st of March from a correspondent who was an eye-witness of the occurrence. He says:—"On the 1st inst. (March), near the village of Lacofranco, a flash of lightning struck the line wire about midway between two poles. The current divided and rushed

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along the wire to either pole, completely destroying the whole of the wire short up to the insulators, where, with a loud report, it jumped to the iron poles and made earth. The length of wire destroyed was 85 yards. The size of wire was No. 8 B.W.G. galvanised iron. The two ends have a purplish hue, and are like hardened steel. The cups of the insulators (white porcelain) were broken, the upper parts being covered with a purplish metallic-looking coating radiating from where the line was attacked. The coating is thoroughly burnt into the glaze of the porcelain. The inside of the cups nearest to where the electric fluid sprang from the line to the iron pole is covered with a fine dark metallic-looking deposit, which is also burnt into the porcelain."

Calcutta International Exhibition.—Communications recently received from the Vice-President of the Executive Committee at Calcutta (the Hon. Colonel S. T. Trevor, R.E., joint secretary, Government of Bengal, Public Works Department) are to the effect that all the necessary annexes in course of erection adjacent to the India Museum in connection with this exhibition will be completed by July or August. A large space on the Maidan, facing the musem, has been enclosed, and will be devoted specially to machinery in motion, agricultural implements, &c. Gas and water will be available throughout the building. The arrangements in regard to lighting are now under consideration. It is proposed that, for this purpose, the electric light should be employed. A deep reservoir, covering an area of nearly 90,000 square feet, will serve for exhibiting specimens of native boats, and for displaying diving apparatus, life-saving apparatus, including boats and steam launch mahinery. The Public Works Department of the Government of India has communicated with the governments of the several presidencies and provinces requesting them to obtain from the railway authorities under their control special rates for the carriage of goods intended for the exhibition. The interest shown in the undertaking by the foreign consuls, and the number of applications for space received from all parts, ensure the complete success of the exhibition as an international display. In considering the allotments of space, priority will be given in accordance with the dates of the applications received through the official agent, 4, Westminster-chambers, Victoria-street, London.

Lightning Conductors.—Something recently stirred up the good people in Edinburgh to inquire into the condition of the lightning conductor supposed to keep guard over the spire of the General Assembly Hall in that city. Accordingly a "steeplejack" was called in and sent to the top of the said spire, some 240 feet above *terra firma*, with instructions to attach a copper wire to the upper end, and thus enable the conductor to be tested. The latter appears to have been put up some 28 or 29 years ago, and to have consisted of a $\frac{3}{4}$in. copper rod, connected by screwed joints. Upon testing the conductor, by sending a current through it *viâ* the copper wire, its resistance was found to be as much as 800 ohms, at least, so our contemporary, the *Scotsman*, states. This was, of course, sufficient to condemn the rod at once, and accordingly arrangements were at once made to fix a new copper wire rope conductor, five-eighths of an inch in diameter, which, after reaching the ground, was carefully soldered to a water main. When this was completed, the resistance of the metallic circuit, consisting of the test wire and the new lightning conductor, was discovered to be somewhat less than three-tenths of an ohm; and when the earth connection was included in the circuit the resistance did not exceed one ohm. It may, therefore, be assumed that the spire is now, for the first time, thoroughly protected against lightning, while the condition of the new conductor can be learned at any time without undertaking the serious task of ascending to the top of the spire. The work has been satisfactorily executed by Messrs. Ritchie and Son Leith-street, Edinburgh, under the direction of Mr. Robertson, of Her Majesty's Office of Works. We have frequently alluded to the urgent necessity for periodical tests being made of the conductivity of lightning rods. There are many conductors in no better condition than that mentioned above, and which, instead of being a safeguard, are positively dangerous.

The Cost of Gas Lighting.—The following figures, taken from a report recently presented to the Streets Committee of the Commissioners of Sewers by their engineer, Colonel Haywood, will prove of interest to electric light engineers, though they deal wholly with gas lighting. The report relates to the experimental lighting of Fleet-street by Messrs. W. Sugg and Co., which was commenced some few months ago. It appears that each lamp encloses three flat-flame governor burners, two of them consuming 10, and one 5 cubic feet of gas per hour. They are so arranged that the central burner can be kept lighted, and the two outer ones extinguished. The illuminating power of each lamp, when the three burners are fully lighted, is stated by Messrs. Sugg and Co. to be equal to 80 candles. The 5ft. bat's-wing burner in common use in the City is said to produce a light equal to about 14 candles. The illuminating power of the improved lamps is, therefore, about five and three-quarter times that of the ordinary burners. The relative cost of lighting Fleet-street appears to be as follows:—By the system generally in use, the cost of each lamp, including lighting and extinguishing, is now £4 10s. 4d per annum, or a total charge of £126 9s. 4d. for the 28 lamps. By the experimental system (one 5ft. burner only being alight after midnight), the cost as given by the gas company is 67,820 cubic feet of gas per annum, at 3s. 2d. per 1,000 = £10 14s. 9d.; lighting, extinguishing, and maintenance per lamp, £2 5s.; total per lamp per annum, £12 19s. 9d.; total for 28 lamps per annum, £363 13s. The expense by the ordinary system being £126 9s. 4d., and by Messrs. Sugg and Co.'s system £363 13s., it appears that the latter is 2·87, or nearly three times the cost of the former. The general result appears to be that Messrs. Sugg and Co.'s system gives between sunset and midnight about five and three-quarter times as much light, and between midnight and sunrise the same light as the ordinary lighting does, and at about three-times the cost of the ordinary lighting. The cost of lighting the arterial thoroughfares in the City varies considerably, according to the widths of the streets, but may be taken on the average at about £530 per mile by the present system, and it would be about £1,500 per mile according to the experiment now under trial in Fleet-street.

Fast and Slow Telegrams.—A Proposal.—In *The Times* of Monday last, Mr. Latimer Clark makes the following proposal:—"As there is a near prospect of a reduction in the cost of telegrams," he says, "it appears a suitable time to call attention to the advantages, as well as the economy, which would be obtained by a division of messages into two classes, slow and fast. The effect of employing the telegraph as the ordinary medium of business communication, and of thereby doubling and quadrupling the present number of messages, must be to crowd the lines with work and to greatly retard the time of delivery, so that we must no longer count on that celerity of transmission which has hitherto constituted the distinguishing feature of the telegraph, and which has given it such inestimable value. In-

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crease in the staff and number of wires and the use of the best modern appliances will do much to remedy the evil, but the space available for poles or wires is limited, while the increase of telegraphy has not yet approached any limit. I would, therefore, advise that two classes of messages should be introduced—express telegrams and ordinary elegrams, corresponding in their use to the express trains and goods trains on a railway. The express telegrams, written on paper of distinguishing colour, should take precedence in transmission over ordinary messages everywhere and at all times; the ordinary traffic should only follow in its turn. The price of the express telegrams should, I think, be so regulated that they should not form more than from 5 to 6 per cent. of the whole traffic, and to effect this I assume that it would be necessary to charge at least eight or ten times the ordinary tariff. On the other hand, if the price were so regulated that they formed about 20 per cent. of the whole number, the receipts would be so much increased that it is probable that the introduction of sixpenny telegrams might be effected without any sensible loss to the revenue, or without any sacrifice of speed in those cases where rapid transmission is desired and is worth paying for. While introducing sixpenny telegrams, I assume, as a matter of course, that the opportunity will be taken of abolishing the custom of writing the address in the form from A to B, and of thus giving two addresses gratis. The address should be similar to that of an ordinary letter, and the address of the sender should form part of the message, as is done in all other countries." Our readers will find this question dealt with in our leading article.

The American Bell Telephone Company.—At the annual meeting of this company, held at Boston on the 27th March, it was stated that the total earnings for the year amounted to 1,576,031·57dols., against 1,001,924·91dols. in the previous year. The expenses were 603,987·29dols., against 439,862·76dols. for the year preceding; net earnings for the year, 972,044·28dols.; balance of income from previous year, 126,034·58dols.; total, 1,098,078·86dols. The total of the previous year was 606,555·01dols. Dividends paid, 595,000dols.; carried to surplus account, 334,997·32dols.; balance of income account, 168,081·54dols.; total, 1,098,078·86 dols. The sales of instruments for export had decreased, and were likely still further to decrease, as foreign countries were making good instruments of their own. The royalties from manufacturers now go to the manufacturing branch. Local companies in New York, Chicago, San Francisco, and Boston were all paying dividends. All of the Dominion of Canada, exclusive of Newfoundland, was supplied by the American Bell Company, and dividends were to be expected from Canada. The legal expenses of the company had been heavy during the year. The report of the treasurer congratulated the company on the fact that the courts had decided that the Dolbear condenser telephone receiver, so-called, infringes on the Bell patent, and an injunction had been issued; also upon the opinion of Justice Gray that the Bell patent had all the breadth that had been claimed for it, and covered microphones and instruments that employ electrical undulations. The People's Telephone Company, using a carbon transmitter, had set up lines in New Jersey, and the report stated that an action on the case called forth the most careful examination that had ever been given to the principles of the various instruments, and gave additional proof that the microphone and other things claimed under the Bell patent were authorised. The case had since been decided in favour of the Bell Company. The underground wires in Boston had been found to transmit distinctly only for short distances, and it would be necessary to devise further improvement before they could be made available to any extent. It was voted that the capital stock of the company be increased from 7,300,000dols. to 9,800,000dols., and that new shares be allowed on the basis of one new share to each holder of the old ones. Incidentally it was mentioned that no less than two million miles of overhead wires had been added to the company's system during the year.

Electric Lighting and the Board of Trade.—The following letter from Mr. E. H. Johnson, vice-president of the Edison Company of New York, appeared in *The Times* of April 7. It has reference to letters from Mr. Arnold White, secretary of the English Edison Company, and Mr. Mackenzie, of the Metropolitan Brush Company, which appeared in previous issues of *The Times*, and the former of which we reproduced at page 479 of our last issue. Mr. Johnson says:—"The essence of the question seems to be—What method of charge will best develop and insure to the users of the electric light the benefits of economic improvements? This question resolves itself into two heads. First, whether the development of the burners be the best promoted by a method of charge which interests the undertakers in its economy, or by that which, as in the gas system, enlists them on the side of its wastefulness. In the first case, the development of the burners would yield to the undertakers an increased profit, while in the latter case it would reduce the profit. In the one case the price is reduced by virtue of the higher producing power of a certain investment and by greater consumption; in the other only by reason of the greater consumption. The theory of the parliamentary Bill, that the development of the burner will be best effected by leaving it to the general public rather than to those more vitally interested, would seem to be sufficiently contravened by the history of the gas burner, the development of which has only become active with the introduction of the incandescent lamp, thus proving that the public have left its improvement to the gas undertakers, and they now only take it up in self-defence. I maintain, therefore, that the improvement of the electric burner will be more rapid in the hands of undertakers whose dividends depend upon it than if left to the general public, which can only reap a benefit in its individual capacity. The argument that the public does not benefit by the increased dividends of the undertakers does not avail against my proposition, since legal limitation and competition as between the electric light companies and the gas companies will compel the undertakers to divide with the public by a gradual reduction of the price. Secondly, whether best check is had upon the undertakers by a system of charging for that which is actually bargained for—*i.e.*, light, or by a system which, like the gas system, sells to the consumer something from which he may in his own way produce light. In the one case he has only to measure the final product. In the other he has a more or less reliable record of the number of units of energy from which he has obtained an unknown quantity of light. But Mr. Mackenzie asks, 'How can we measure it?' The plan is a simple one. The lamps provided by the undertakers are rated at so many candles each. Their consumption of energy is definitely known and fixed with a current of a given strength. Thus, in the Edison system the standard lamp is of 16 candle-power. This lamp requires three-quarters of an ampere of current to yield 16 candles of light per hour. The bill to the consumer is based upon these known standards. If the consumer has reason to question the accuracy of his bill, he has only to count the number of lamps in use for a given number of hours, multiply the two together, and the total by 16 (the standard of the lamp), and he will have

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an absolute check. For illustration, the undertakers present a bill for 48,000 candles of light. The consumer counts his lamps and takes note of the number of hours they burn, and finds that he has 10 lamps burning 10 hours per day, or one lamp for 100 hours. This for 30 days gives him 3,000 lamp hours. This, multiplied by the company's own standard of 16 candles, yields 48,000 candles, and he has proof positive that the bill is correct. If the bill were more, he has proof of its error, which the undertakers would be bound to accept, since no matter what number of amperes of current the meter may have shown to have passed, the calculation of the amount of light supplied is made from the basis of so much current per lamp to produce 16 candles of light per hour. If the undertakers object to the consumer's count, they can make it themselves, or in other ways test the accuracy of their meter. Compare this with the check upon a gas meter. The bill is for 2,400ft. of gas. An examination of the meter shows the record to be in accord, but does that prove that the consumer has had 48,000 candles of light? No; the larger proportion of his gas may be escaping and not supplying light at all. Or, if not escaping, his burners may be so wasteful that, instead of getting 16 candles from a 6ft. burner, he may, as we all know, be only getting eight or ten. Why, then, perpetuate a crude and imperfect system offering no real check when a perfect and absolute one is available? The candle-power of the lamps may be tested in many ways, but this like many other details takes care of itself where the undertakers are interested in their efficiency. If the lamps were under candle-power it would be because an insufficient current was passing through them. This would show upon the meter; and the bill would be proportionately decreased—a matter which the undertakers would speedily remedy in their own interests. If they were above their proper standard, thus giving the consumer more light than he desired to pay for, the lamps would be more quickly destroyed, and since the Edison system contemplates the supply of lamps free of charge to the consumers, it would speedily remedy this defect to save itself a heavy charge for lamp breakage."

Electricity Afloat.—Many of our readers are, no doubt, familiar with the outward appearance of H.M.S. "Rainbow," the head-quarters of the members of the 1st London Corps of the Royal Naval Artillery Volunteers, which lies at her moorings off the Victoria Embankment, a short distance below Waterloo Bridge. The old boat (she served in the Crimean war, we believe) has been the scene of considerable gaiety during the past week, and for the first time in her existence has been lighted throughout by electric lights. The occasion of this gaiety has been the giving of a series of theatrical performances by the members of the above corps. On arriving on board we were astonished to find how dexterously the main deck had been transformed into a temporary theatre, prepared, as we were, for an exhibition of some of the proverbial neathandedness of "Jack." The auditorium, if we may so call it, was lighted by a centre pendant containing six 10 candle-power Swan lamps, and another ornamental pendant of extremely handsome appearance. It consisted of a frosted glass globe of the same shape and size as an ostrich's egg, inside which a lamp or lamps were placed; the peculiarity of the globe consists in the fact that there is no brass or metal work about it at all, and it is simply enclosed by silken network, which terminates in a flexible suspension cord, inside which the leads are hidden. The glass globe takes to pieces when it is required to withdraw the lamp. This ornament is due to Mr. Vanderweyde, of Regent-street, W., and is intended as an imitation of the ostrich eggs so often to be seen hanging in the mosques of the East, where they are an object of veneration. It is very effective as a pendant, and would lend itself readily to the decoration of interiors. Two or three single lamps were distributed about the deck, at the refreshment bar, and elsewhere, in the form of table lamps, and so on, all of them having switches by means of which they could be readily turned on or off, as required. The stage was illuminated by footlights, and also by another row of lights placed some distance back, so as to throw their light on the actors from above, whilst one or two were utilised at the side to give light to the stage carpenters, &c. The total number of lights employed was 40, all Swan's, of 10 candle-power. They were fitted up and the whole arrangements designed and carried out by Chief Petty Officer Wharton, of Messrs. Laing, White, and Wharton, of Holborn-viaduct, agents for the Swan United Electric Light Company, to whom the credit of the success attained must be accorded. As evidence of Mr. Wharton's energy and resource, we may mention that he only had the order at one p.m. on Wednesday week, and that by six p.m. on the next day the whole installation was complete and ready for running. The current was furnished by twenty-two cells supplied by the Duplex Electric Light Company, of Leicester-square, W.C., the E.M.F. of which would be about $1\frac{3}{4}$ volt each. These were placed on the upper deck, and coupled up to a switch behind the scenes in such a manner as to enable 17, 20, or 22 to be thrown into circuit, according as they were required. The footlights, the lamps in the auditorium, and the remaining lamps were also connected up to separate circuits, so as to enable Mr. Wharton to regulate them to a nicety from his post behind the scenes. The lights were all connected up in multiple arc. On the occasion of our visit the performance commenced with "Meg's Diversion," an amusing piece which was much appreciated by the audience, and concluded with a musical extravaganza under the title of "The Fifteenth Century," the original composition of two members of the corps, the words being written by Mr. C. F. Fuller, and the music by Mr. Campbell Williams. Judging from the laughter and applause which continued throughout this part of the evening, both words, music, and acting appeared to be thoroughly enjoyed, as we think they deserved to be. During the last act of "The Fifteenth Century" a ghost scene is introduced, in which the electric light did good service. At a given signal, and when the feelings of the audience have been worked up to ghostly pitch, a gong is heard to sound, out go the whole of the lights, and the audience are introduced to an unearthly-looking portrait, the head of which addresses ghostly words to the actors. A gleam of moonlight falls directly on the features, and adds to their ghastliness. It is unnecessary to say that the face of a real portrait had been cut away, and the head of a living person inserted *pro tem.*, the whole affair of the ghost being a practical joke, played by one section of the actors on the rest. The gleam of moonlight was supplied by a Swan lamp in a temporary holophote projector, with a green glass in front. The effect was capital. Throughout the evening the lamps burned as steadily as could be wished, and gave quite their full candle-power, if not more. That they were under complete control was evident from the first. Chief Petty Officer Wharton is to be congratulated on the success of his arrangements, which, considering the short time at his disposal, were excellently planned and carried out. For ourselves, we shall retain a lively recollection of the pleasure experienced on the occasion of our visit to H.M.S. "Rainbow," and of the uniform courtesy of the members of the Royal Naval Artillery Volunteers.

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SOME ELECTROSTATIC & MAGNETIC RELATIONS.

BY OLIVER HEAVISIDE.

1. When we confine ourselves to a single dielectric, as air, for example, and do not take into consideration the modifications produced in the distribution of force by the presence in the electric field of dielectrics of specific capacity differing from that of the main body of the field (which amounts practically to having no variations of specific capacity unless it may be in very weak parts of the field, where no sensible effect would be produced), the relations of the principal electrostatic quantities are capable of simple expression, and of more or less easy comprehension, according to circumstances. We have in the first place the electrostatic force, which is by far the most important; and next, two auxiliary functions, the electricity and its potential.

In an electric field in equilibrium a small charged conductor in general experiences force at any place, and the electrostatic force is the force that would act upon a unit positive charge placed at the point considered and supposed not to modify the field by its presence; the ordinary electrostatic unit of electricity being so defined that two charges of amounts e_1 and e_2 at distance r apart experience a repulsion of magnitude $\frac{e_1 e_2}{r^2}$.

Electrostatic force is thus a vector, having direction as well as magnitude; and the electric field becomes completely known by following the direction of the force from point to point, thus travelling along a line of force; then doing the same for another line of force, and so on; and ultimately dividing the whole field into tubes of force, a tube being everywhere bounded by lines of force, there being no force normal to its surface (save when cut across), and such that the integral amount of force crossing any section of a tube is the same, a constant for the tube. Now these tubes are all unclosed, or start somewhere and terminate somewhere else, usually upon conductors, and at the ends of a tube is supposed to reside free electricity. According to Maxwell's remarkable theory there is a real displacement of electricity all along a tube of force, proportional in amount to the strength of force at any place, and in the same direction in general (*i.e.*, in an isotropic medium, whose specific capacity does not vary in different directions), the whole displacement across one section being the same as that across any other. If this amount be e for a certain tube, then at the commencement of the tube there is an amount e of positive, and at its end an equal amount of negative electrification, or of *free* electricity, to distinguish it from the electricity displaced in other parts of the tube, which gives no indication of its presence, for a similar reason that a uniformly magnetised magnet shows no signs of "magnetism" save at the ends of the lines of magnetisation. But in the following we shall simply refer to it as the electricity.

2. However, quite apart from this hypothesis, however probable it may be, which so neatly harmonises the equations of electro-magnetism, and may almost be considered as a truth (whose recognition was, perhaps, hindered by the absurd 4π multiplier connecting electric force and surface charge, viz.:—Surface density (or displacement) $= \frac{1}{4\pi} \times$ force $\times$ spec. capacity, which is just as reasonable as it would be to say that, in a conductor,

$$\text{current} = \frac{1}{4\pi} \times \text{E.M.F.} \times \text{conductivity}),$$

we may always determine the distribution of electricity from the convergence or divergence of the force; and from a mathematical point of view, when we are only concerned with the quantitative and directional relations, we may consider the electricity to have no other meaning than to express the amount of such divergence or convergence at any place.

Describe any closed surface, and measure the integral amount of force leaving it. This (divided by 4π) is the measure of the amount of electricity contained in the enclosed volume. Applying this to the unit volume, we see that the volume density ($\times 4\pi$) = excess of amount of force leaving over that entering the volume. If this be positive, there is evidently a divergence of force on the whole at the place considered; if negative, a convergence. Let R denote the electrostatic force, and ρ the volume density of electricity, then we may say $4\pi\rho = -$ conv. R, or, $=$ div. R, where we use conv. and div. as abbreviations to be understood as follows: In terms of the components X, Y, Z, of the force, we have

$$4\pi\rho = \left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right).$$ (Theorem I., p. 55, *ante*.) The expression on the right hand side of this equation (with the $-$ sign prefixed) Maxwell called the "convergence" of the force; it is really the integral amount of force, taken algebraically, *entering* the unit volume; but since + convergence indicates negative electricity, we may as well use the term "divergence" for the same quantity with + sign prefixed, as it appears in the above equation, in fact; thus, if the amount of divergence be positive, it indicates positive electricity. Electricity is thus a scalar (directionless) quantity of one degree lower dimensions than electrostatic force as regards length.

The other auxiliary function to R, viz., the electrostatic potential, say P, is one degree higher than R as regards length, and is such that $P = \Sigma \frac{\rho}{r}$. Divide the space where there is electricity into small parts; divide the charges in these parts by their distances from a given point, and take the sum of all the quotients; the result is the value of the potential P at the given point. Since ρ is scalar, so is P.

We have also the relation $R = \text{v.}\Sigma \frac{\rho}{r^2}$ between force and density, the summation being now of vectors drawn radially from the charges. (In v. Σ the v. is to call attention to the fact of the summation being of vectors.) Likewise there is the very important relation, $R = -\nabla P$, which translated into words says that the force is the vector, rate of fastest decrease of the potential, which we may call simply the space-variation of the potential. At any point, find which way the potential falls fastest; it is the direction of the force, and its magnitude is the rate of decrease.

Thus we have, in descending order,

Scalar. Vector. Scalar.

$$P = \Sigma \frac{\rho}{r}; \quad R = -\nabla P; \quad 4\pi\rho = \text{div. R}. \quad . \quad (1)$$

Although we have only spoken of volume density, we may easily pass to surface density by the same method of considering the amount of force leaving a closed surface, which in this case must be intersected by the electrified surface where the density is required.

3. If we compare the relations in equation (1) with the corresponding relations between A, B, and C in a current system, C being the density of current, B the magnetic force, and A the vector-potential, we observe similarities and differences. For we have

Vector. Vector. Vector.

$$A = \text{v.}\Sigma \frac{C}{r}; \quad B = \text{curl A}; \quad 4\pi C = \text{curl B} \quad . \quad . \quad . \quad (2)$$

In (2) A, B, and C are in descending order as regards length dimensions, as are P, R, and ρ in (1). Again, as P is the potential of ρ, so is A the potential of C. So far there is similarity. But whereas in (2) all the quantities are vectors, in (1) we have two scalars and a vector. Also, whilst in (2), C is derived from B in the same manner as B from A, in (1) as we pass from the vector R to the scalar ρ we have the operation divergence, and from the scalar P to the vector R the operation of space variation. The relations in (2) are thus much more uniform than in (1).

Now, as has been discussed in former articles, if we form additional auxiliaries in the series belonging to the current system, below C and above A, we have the same properties repeated. Thus, if we form the quantity D = curl C, we shall have B = vector-potential of D; just as (4π) C = curl B and A = vector-potential of C. And if we form the quantity A_0 = vector-potential of B, A_0 being thus one degree above A, we shall have A = curl A_0 (with a 4π factor). And we may get rid of the remaining irregularity of appearance

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of 4π, and make the relations uniform all along the series, by making the potential of a quantity $x = \Sigma\frac{x}{4\pi r}$ instead of $\Sigma\frac{x}{r}$; which in our present case amounts to making the integral amount of force emanating from a magnetic pole of strength m numerically equal to m.

4. What are now the corresponding properties in the series P, R, and ρ, when we form auxiliaries, one below ρ, another above P? Their existence is somewhat masked by the want of uniformity in (1), but they exist nevertheless.

In the first place, form the vector function R_0 one degree above P as regards length dimensions, such that $R_0 = \Sigma\frac{R}{r}$. Then we shall have the following relation between R_0 and P, viz., $4\pi P = \text{div. } R_0$; or, in words: The electrostatic potential ($\times 4\pi$) equals the divergence of the vector-potential of the electrostatic force.

Analytically, if the components of R_0 are X_0, Y_0, Z_0, we have by the definition of R_0 above

$$X_0 = \iiint\frac{X}{r}dV; \quad Y_0 = \iiint\frac{Y}{r}dV; \quad Z_0 = \iiint\frac{Z}{r}dV; \quad (3)$$

dV representing the element of volume. Therefore, by the definition of divergence, and by (3) div.

$$R_0 = \frac{dX_0}{dx} + \frac{dY_0}{dy} + \frac{dZ_0}{dz} = -\iiint\left(X\frac{dr^{-1}}{dx} + Y\frac{dr^{-1}}{dy} + Z\frac{dr^{-1}}{dz}\right)dV,$$

where we introduce the $-$ sign on transfering the place of differentiations from the point where R_0 is measured to dV itself, at the other end of r. Hence, by integrating by parts,

$$\text{div. } R_0 = -\iint\frac{R_n}{r}dS + \iiint\frac{1}{r}\left(\frac{dX}{dx} + \frac{dY}{dy} + \frac{dZ}{dz}\right)dV;$$

where R_n is the outward normal component of R at the bounding surface; or

$$\text{div. } R_0 = 4\pi\iint\frac{\sigma}{r}dS + 4\pi\iiint\frac{\rho}{r}dV = 4\pi P,$$

as was to be shown, σ and ρ representing the surface and volume densities of electricity.

5. In the next place, form R_1, a vector representing the space variation of ρ, or $R_1 = -\nabla\rho$; R_1 thus bearing the same relation to ρ as R to P, and inquire what relation R_1 bears to R. The answer is, $R = \text{v.}\,\Sigma\frac{R_1}{r}$, or in words: The electrostatic force is the vector-potential of the space variation of the electric density.

Take one component of R at a time. For the x-component X we have

$$X = -\frac{dP}{dx} = -\frac{d}{dx}\iiint\frac{\rho}{r}dV = \iiint\rho\frac{dr^{-1}}{dx}dV$$

where we originally perform the differentiation at the point to which X belongs, and then, in the last integral, transfer it to dV. Hence, by "parts" integration

$$X = \iint\frac{l\rho}{r}dS - \iiint\frac{1}{r}\frac{d\rho}{dx}dV, \quad . \quad . \quad . \quad (4)$$

where dS is an element of the bounding surface, and l the cosine of the angle between the normal outward and the x-axis. Disregarding the surface-integral, by extending the volume-integration over all space, and writing X_1, Y_1, Z_1, for the components of R_1, we have, by (4), and remembering that $X_1 = -\frac{d\rho}{dx}$, &c.

$$X = \iiint\frac{X_1}{r}dV; \quad Y = \iiint\frac{Y_1}{r}dV; \quad Z = \iiint\frac{Z_1}{r}dV.$$

Hence, by compounding the three left-hand members to form R, and X_1, Y_1, Z_1, to form R_1, we obtain simply $R = \text{v.}\,\Sigma\frac{R_1}{r}$, the required result.

(TO BE CONTINUED.)

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XIX.

Another way of taking the test for insulation resistance by loss of charge is preferred by some electricians, and a comparison of the two methods will show that there is much to be said in its favour. The fall of potential is measured in both cases—that is, the potential of the cable charge, after certain periods of leakage, is observed by the deflections arising from the discharges taken at the several intervals; but in the form of test now to be briefly considered a condenser is used for assisting in this purpose, whereas, as we have seen in the last number, the cable was discharged directly through the galvanometer without any other appliance. By this means it is thought that an advantage is gained in the fact that we are enabled to obtain the consecutive discharges without charging the cable more than once for all, and, therefore, that we can note the diminished potential, minute after minute, without any risk of want of uniformity in the observations. Each of these is the result of the regular fall of potential from one full charge. The cable is thus tested under conditions most favourable to the absence of change, and, moreover, the operation is much more quickly performed. With the condenser the test can be taken either with or without repetition of charge, but without condenser every discharge is the result of a fresh charge, and even if the cable were not in any way affected the battery is liable to variation, though it may be, perhaps, of small amount. The principle is exactly the same in both methods, and the deflections that are produced cannot but be considered equally true, since, if the cable must be fairly put to earth after each discharge, as we have shown in our account of the discharge test, the condenser in the other case must be as carefully discharged between every two observations. At any rate, in both cases this point is always attended to—it is, probably, of less consequence, after all, for the cable than for the condenser.

The test now before us is simple enough. The cable is charged from the battery for ten seconds, and the full charge is at once caused to pass to the condenser, and is thence discharged through the galvanometer, giving the deflection for full potential. The battery is now disconnected from the cable, and the latter commences to leak, as before described. After one minute the charge (or, rather, a portion of it) as then existing is passed into the condenser and a second deflection is taken, and the operation repeated at the necessary intervals. Now, when a cable (or condenser) is charged and then brought into communication with another condenser, the charge is distributed between them in the ratio of their several capacities, but both are charged to the same potential, though they may be of very different capacities; so that, if the cable be of much greater capacity than the condenser, a much larger quantity of the charge remains in it than can pass to the latter. If they were equal in capacity half only of the charge could pass, and thus, as whatever be the quantities, still the potential is the same, it is not necessary to recharge the cable between the observations. The object of this and the former test is to obtain a comparison or ratio of the deflections representing the potential at the time. It may be remembered that in the first of these tests the deflections represented the potential and the actual quantity in the cable at the particular moment when discharged; in the second (the present test) they also represent the potential, but a portion only of the charge remaining in the cable. The effect in either case is the same as that which would be produced by a constant current at a given potential.

The connections for the present form of test are shown in Fig. 41. The various keys, &c., are now so familiar that it is unnecessary to indicate separate parts by letters. They are accordingly omitted where not absolutely essential. In this figure the shunt has been accidently left out; its place, of course, is well known to the reader. The instructions given in the last number for taking the discharge test will require but little variation here. The battery key will not, however, be clamped down, but merely depressed; first, when taking

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the full discharge, and again once for all when charging previous to the leakage of the cable, although it is not absolutely necessary to charge more than once, and take the full discharge and the others consecutively. When the minutes severally expire, the Lambert key comes into play, and the same carefulness as suggested in the previous discharge test is necessary, namely, not to confuse the contacts in charging and discharging the condenser. The cable side of the key is first touched down and released, and the other immediately depressed; the condenser must receive the charge at the cable potential exactly at the minute, and must be discharged without allowing time for any variation in itself. It is then proper to short circuit the condenser by its plug until the next minute has nearly expired. The object, of course, is apparent. The formula is worked out as before.

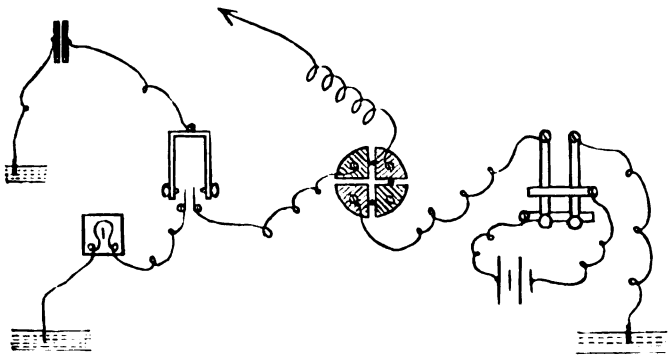

FIG. 41.—Insulation resistance Discharge test with Condenser.

We have now to show how the insulation resistance test is taken with the electrometer, and although it is not so generally employed as those already explained, it must be acknowledged to be more interesting, for the reason that the fall of potential is continuously observed and not merely determinable at certain intervals, the quadrants of the electrometer accurately representing the condition of the cable at any time during the operation. The principle of the use of this instrument has been fully considered in an early number of this series, and it is important that the practical execution of the test should be familiar to the student since it is sometimes suddenly called for, and there is but little opportunity for mastering its details in some testing rooms. We give a diagram of the connections for one form of test in this number. In Fig. 42 the same principle is illustrated as that involved in the figure given in the earlier number just mentioned. There is another form of this test to be explained later—a variation involving reversed charges. It is a very delicate one, and one by which a minute fault that has escaped discovery in the course of other forms has in some instances been proved to exist in a section of cable. The connections in our figure are here arranged as simply as possible, and we can conveniently test two or even three sections at the same time, which is sometimes very useful. There may be a dozen machines at work and half a dozen lengths besides in the tanks, the latter being sections previously run

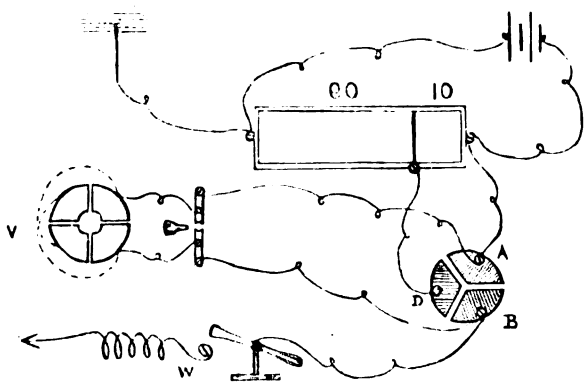

FIG. 42.—Insulation resistance test with Electrometer.

through the machines, and which are tested, perhaps, three or four times a week. It is seen on glancing at the figure that a high resistance is inserted between the poles of the battery; this may be a slide resistance of 100,000 units, and answers, besides other purposes, that of enabling us to have a practically wide range for the deflections, an object secured by a device of Professor Fleeming Jenkin, and which is called an "Inferred Zero." This device is referred to in other publications as being achieved by a somewhat different method from that explained here, but the result is the same. It will be remembered that in a recent galvanometer test we found it necessary to extend the range on the scale there used so as to get as large a deflection as possible. But the zero on that scale was in the centre, and in the electrometer scale it is at the end, so that no further extension can be made. Instead, then, of lengthening out the scale, an imaginary or inferred zero is obtained by taking a deflection from the electrometer with a potential equal to 1-10th of the full battery potential and multiplying the figure by 10. For example, a deflection of 500 would give us 5,000 as our zero or starting point, the value representing the full potential to which all other deflections are to be related or compared. It will be seen at once that the larger the deflections are the greater must be the value of any difference between them; and as we are to observe the loss of charge, it is a point of much importance to have the proportions as large as possible, since the fall of potential is comparatively slow.

The object is arrived at by the following arrangement, which will be understood by inspecting the diagram. We have here a plan of the connections for testing with one current only, as in the earlier number. Similarly also one pair of quadrants is to be joined to the cable, and the other to the battery or earth as a standard for comparison of potentials. The resistance-box contains 100,000 units, and we have supposed the 100 coils, each of 1,000 units, to be divided in two portions, the one having 10,000, and the other 90,000. At one end of the box we have one battery pole attached, at the other end the other battery pole and also an earth wire putting both battery and box to earth. Following the conditions governing the current the potential will be that of the whole battery, or "full" at the top end, and will fall regularly down through the equal coils in the resistance-box to *nil* or zero at the end which is to earth. Therefore, at a point such as that between the partitions, where 90,000 are shown separate from the other 10 the potential will be 9-10ths of the full potential, or that where the lead comes from the battery. If we call the full potential 100,000, that at the point where the other lead joins will be 90,000. By following the connections in the figure, it is seen that by means of the three-way piece or commutator either of the leads from the resistance-box and battery can be made to connect with the quadrants of the electrometer V. The dotted lines are intended to represent the wires, which join the quadrants in two separate pairs. If we insert a plug between D and B in the commutator, then it is seen that one pair of quadrants connects with the battery lead through A, and the other pair is joined to the lead through D. The first pair will be charged to the full potential, and the other pair will take up 9-10ths of the full charge. The student knows that if both pairs of quadrants were charged to the same potential there would be no deflection of the aluminium needle. Again, if one pair had been charged to full potential, and the other pair were to earth, the deflection would be much too great to be of any use; it was, therefore, necessary to have a readable deflection which should be a certain definite part or proportion of the value for full potential, that we might have practically a wide range of scale and ample deflections for relative comparison. Now we have one pair of quadrants at full potential, say valued as 100,000, and the other at a potential of value 90,000. The difference of potential of the two opposing pairs is 1-10th of the whole battery power; and assuming the cells to number 100, and to be all alike, we may say that we have the deflection from 10 cells, and multiplying this by 10, the working or inferred zero is obtained.

We see from the connections that the battery is permanently joined to one pair of quadrants (through A), and that if the short circuit plug were inserted both pairs would be

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equally charged. If a plug were placed between A and B the same thing is achieved, as the one pair would be charged from A, and the other from B, through A. We only intend the short-circuit plug for general use, and in taking the test shall not employ it. We now suppose the inferred zero to have been found, and if the deflection were 500, it is 5,000. The plug will have been removed from between D and B, and will be inserted between A and B. The battery is now connected to both pairs of quadrants, and also to the distributor, which is ready to be turned on to the cable terminal at W. Having a good seconds watch before us, we wait till the hand points to 45 seconds, and at this instant turn on the distributor to the terminal. The cable now shares with the two pairs of quadrants in the charge from the 100 cells, and will be charged to the same potential. At the end of 15 seconds we remove the plug in the commutator, and thus separate the cable and one pair from the battery, leaving the standard pair still under charge. The former and the cable being both connected together must remain at the same potential, the one as the other, and as the cable gradually loses its charge, so does the pair of quadrants attached to it, and consequently the needle deflecting causes the spot of light to pass down the scale. We should have said that the spot is arranged to be at its starting point or place of rest when both pairs of quadrants are equally charged, this point being at 0 at the near extremity of the scale. The inferred zero is also obtained from this point, and when we called this zero a starting point we referred only to its value as a figure to calculate from. If the insulation of the cable is good, as it ought to be, the spot will now travel very slowly; but, if not, it travels quickly, and, perhaps, with jerks. But, supposing all to be well, we permit the cable to leak for 90 seconds and then read the number of divisions shown by the deflection, let us suppose 125. This figure is recorded, and after another 30 seconds we take a reading, say, 175. We have now got our two readings, and the test, in this case called a two minute one, is finished. We therefore turn off the distributor from the cable and short-circuit the electrometer by inserting the proper plug. The two pairs of quadrants are thus maintained at the same potential, and the spot returns to zero. If the short circuit is made with the plug in the commutator, care must be taken that the distributor be turned off first, or the cable will receive a fresh charge to no purpose. In comparing this test with those taken with the galvanometer, the student will observe that the times of observation or the intervals are not the same, but he will see that the same object is attained, and the following explanation will be of service to him :—

The first reading just taken was 125. Now, this shows that out of 5,000 divisions, which really represent the full charge of the cable before leakage, 125 have been counted off; therefore, the charge remaining at the time of reading is 5,000 — 125, or 4,875. This value is that which stands for the first of two fixed boundaries between which we are to measure the rate of leakage. The second reading was 175, and subtracting this from the inferred zero, or 5,000, we have 4,825 as the second fixed boundary separated from the first by an interval of 30 seconds. Here we have the amount of charge left in the cable at two separate periods, so that the ratio or relative proportion of these two values gives us, or is the proportional amount of leakage during the half minute, then $\frac{4875}{4825}$ taken as a ratio shows how much greater is the charge at the commencement of the 30 seconds than at its expiration. Consequently, by inverse reasoning, it shows how much of the charge at any time after beginning to leak has escaped during 30 seconds. To make this plainer, suppose that from a vessel of water holding 1,000 quarts a quantity is drawn off at two periods 30 seconds apart, and say that we first let it escape for 90 seconds, and then find that 200 quarts had gone. There are thus 800 left, and, letting the water run for 30 seconds, let us suppose that 600 quarts in all have escaped, there are consequently 400 quarts left, and 400 ran out during this half minute. Therefore $\frac{800}{400}$, or 2, is the value or figure representing how much the quantity in the vessel at the beginning of 30 seconds exceeded that left at the close, that is, in this case twice. Conversely, half the quantity in the vessel escaped in 30 seconds. We see that the ratio $\frac{800}{400}$ measures the leakage in 30 seconds, and the power to resist leakage (so to speak) is only as 1 : 2, the power to leak is to the resistance as 2 : 1. We have not intended to compare the escape in this example with the fall of charge in a cable in every respect, on several grounds. Our object is simply to establish the fact that the ratio represents the rate of leakage, and we see that the action is an exemplification of compound interest.

From the data which we have now got, and following the explanations given in the last number, the results are obtained. Referring to these remarks on the formula for loss of charge, a word on the fraction given as $\frac{P}{p}$ may be useful. This ratio in the galvanometer tests is that of the deflections, and in the electrometer test is that of the values got by subtracting the deflections from the inferred zero. We observe then, that as the first reading's difference from inferred zero : the second ditto :: the charge of the cable at any potential to the loss in the half minute, and so the remaining value. Conversely, as the second difference : the first :: the loss per half minute, or the remaining charge, : the charge of the cable. Therefore $\frac{P}{p}$ is the ratio of charge to loss per half minute. From this it follows that the greater $\frac{P}{p}$ comes out the worse is the insulation of the cable, P and p being regarded as values. Thus if the ratio were $\frac{8}{4}$ the value of P as compared with p is 2; but if it were $\frac{8}{2}$ this figure becomes 4, and the cable appears as affording a resistance to leakage less in the second case by one half. We are not to regard p, or the denominator of the fraction, as directly representing the leakage, but rather as resistance to leakage, and the whole fraction is to be held as a "bad quality." This test is totally irrespective of the entire length of the cable—the conditions are those of time, capacity, material, &c., and certainly of length, but in proportion only. Of two cables of the same length one might give a larger value for the fraction than the other; it would be a worse cable, that is, if made of exactly the same materials, and altogether uniform with it.

GRAY'S ARC LAMP.

This lamp, which is the joint invention of Mr. A. Gray, M.A., F.R.S.E., Chief Assistant to the Professor of Natural Philosophy in the University of Glasgow, and Mr. Thomas Gray, B.Sc., F.R.S.E., and is made by Mr. James White, Glasgow, possesses some points of novelty which may be interesting to the readers of *The Electrician*. It belongs to that class in which the carbons are made to approach each other by the action of gravity, and are separated by an electro-magnetic controlling apparatus. The upper carbon holder is made sufficiently massive to allow the gravitational action to be but little affected by the change of weight of the carbons themselves. When the lamp is one designed for constant focus, the lower carbon holder is arranged so as to be raised through the proper relative distance by the descent of the upper carbon holder. The motion of the carbons is regulated according to the strength of the current flowing in the arc by a convenient form of electro-magnetic controlling apparatus.

So far the principle of the lamp is similar to that of many others. One main feature of novelty, however, is the employment, in combination with the electro-magnetic appliances, of a hollow drum or ring divided into compartments by partitions, each of which is pierced by one or more orifices pro-

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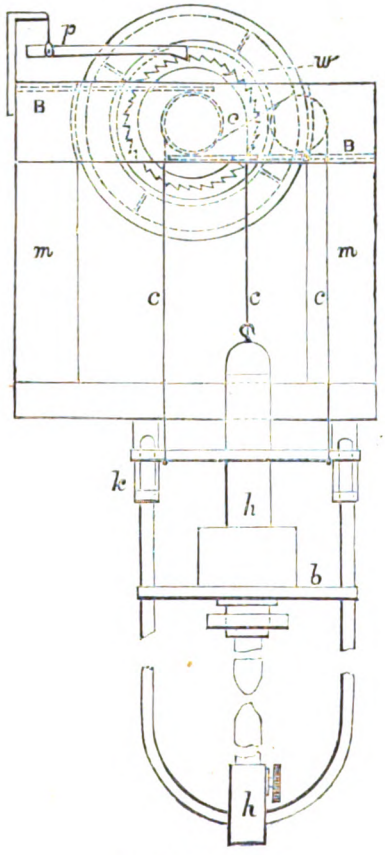
perly placed. The space within the drum, or its equivalent, is partially filled with a suitable liquid, the action of which is to render steady and gradual the movement of the carbons either towards or from one another. This action is very simple. The drum is mounted so that the motion of the upper carbon holder upwards or downwards turns it round on its axis. The liquid is carried round with the drum, and acquires a difference of levels on the two sides, in virtue of which it applies a couple opposing the rotation of the drum on its axis. The couple increases as the angle through which the drum is turned is increased, until, if the drum is of sufficient dimensions, or the liquid sufficiently dense, the couple applied by the liquid just balances that applied by the motor mechanism of the lamp. After equilibrium has been thus obtained the drum will turn round on its axis, in obedience to the couple applied by the lamp mechanism, with a slow motion depending on the rate of loss of head of the liquid in the drum, in consequence of its flow through the orifices. Thus, in Messrs. Gray's lamp, the flow of the carbons towards one another in normal circumstances takes place with a slow,



Gray's Arc Lamp.

uniform motion, the lamp adjusting itself so that the couple applied by the gravity of the upper carbon and its holder preponderates just so much over the retarding couple applied by the electro-magnetic controller that the carbons are fed as they are consumed at the proper rate, under the regulating influence of a small head of liquid in the drum. If, however, any change takes place, in virtue of which the turning motive on the drum in one direction or the other tends to increase, the motion is at once moderated by the regulating action of the liquid, and the steady and gradual feed of the carbons is restored before any perceptible disturbance of the light has taken place.

The form which the regulating mechanism of this lamp has now taken is illustrated in the sketch, which shows diagrammatically the arrangement. The electro-magnetic controlling apparatus is a small Gramme motor, the magnets *m m* and armature *r* of which are wound with coils of thick wire, which are joined in series with the carbons. In order that the lamp may be burned with different strengths of current a coil of thin wire is also wound on each of the magnets and placed as a shunt on the arc in the usual manner, so that its magnetising effect is opposed to that of the thick wire coil. The lamp is thus suitable for use in a circuit in which two or more arc lamps are burning in series. For, assuming that the magnetisation of the magnets is proportional to the current, we have for the equilibrium of the carbons the equation,

$$A C^2 - B C E = L,$$

where A and B are constants, C the current strength in the thick wire coils, E the difference of potentials between the two ends of the thin wire coils of the magnet, and L the couple due to gravity tending to turn the armature, so as to bring the carbons together. If a sudden change in the current strength C takes place, due, say, to the coming into contact of the carbons of one of the lamps, the others adjust themselves so that the difference of the quantities on the left hand side of the equation above is still equal to L; and beyond, perhaps, a brightening of the lamps still burning, no disturbance is caused by the extinction of one of the arcs in consequence of the carbons coming together and ceasing to separate. A simple electro-magnetic arrangement, not shown in the drawing, acts, if the carbons by any accident cease to come together, and cuts out the lamp, inserting at the same time a resistance equal to the average resistance of the lamp, so that other lamps in the circuit may continue to burn as before.

The iron ring *r*, forming core of ring of the regulating motor, is made hollow, as shown by the dotted circles, and is divided into communicating compartments by partitions, so as to be used instead of the hollow drum described above. The hollow space is partially filled with mercury. By this arrangement the use of a separate drum is avoided, and it is more effective and not less compact than the obvious plan of a hollow cylinder contained within the Gramme ring. The current is sent through the ring by means of brushes, B B, which run on a commutator, C, on the spindle of the ring of the motor in the usual manner. Each of these brushes is formed of a large number of strips of very thin copper placed one above the other. Several layers of the strips next the commutator bars are slit at the bearing part into a fringe, so as to give, as it were, a soft pad bearing on the commutator. The spindle of the ring carries at the other end a set of three pulleys, two of which have half the diameter of the third, and are placed one on each side of the larger pulley. Round these are wound in the proper directions cords, *c c c*, made of fine copper wire, which carry the upper and lower carbon holders *h h*, so that while the upper or positive carbon descends a certain distance, the lower carbon holder ascends through half that distance. The rods of the lower carbon holder slide loosely through guides formed by holes in the ends of a crossbar, *b*, carried by the upper carbon holder, but insulated from it, and two brackets, *k k*, fixed to the framework of the lamp. It is, of course, unnecessary for some purposes that the lower carbon holder should be movable, and in such cases the upper carbon holder only is suspended.

The action of the lamp is as follows:—When no current is passing through it, the carbons are held with their points pressed together by the action of gravity. When the current is sent through the magnets and armature of the motor, the armature revolves in the direction tending to lift the upper carbon holder, and thus separates the carbons and establishes the arc. This initial motion of the carbons is regulated by the action of the mercury in the hollow ring; and the feed of the carbons is kept up continuously thereafter by the gravity of the upper carbon holder, resisted by that of the lower carbon holder and the electro-magnetic action of the motor regulated by the liquid in the ring.

To prevent the motor, when striking the arc, or when a sudden increase takes place in the current flowing through the lamp, from producing too great a separation of the carbons, the ratchet wheel *w* is fixed behind the pulleys on the spindle of the ring. A pawl, *p*, suspended by a thin piece of very flexible metal from a fixed support is free to move in the plane of the wheel, and rests by its own weight on the ratchet. When the carbons are separated the pawl is carried to the left by the ratchet until by coming against a stop it is prevented from going further, and thus stops the

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rotation of the armature in the direction to separate the carbons. This initial separation is arranged to be greater than the normal length of the arc, and the continuous regulating action comes thus into play at once. This ratchet is always convenient, as it allows a smaller mercury regulator to be used, but it is more especially wanted when several lamps are burnt in series.

A lamp of the same type, except that the regulator containing mercury is made of boxwood and placed on the same axis as and within the ring of the motor, has been supplied to Sir William Thomson for laboratory and other use. On the occasion of the installation of Mr. Bright a few days ago as Lord Rector of the University of Glasgow, it was temporarily suspended in the Professors' Court and placed in the circuit of the dynamo by which Sir William's house in the University is lighted. The light was beautifully clear and steady, and was not at all affected by the putting on and off of several incandescent lights arranged in parallel circuit with the lamp. A trial of it in the new Bute Hall of the University proved that this form of lamp, because of its great steadiness and silent action, is extremely well adapted for the lighting of large public buildings. This great hall is about 80ft. from floor to ceiling, 144ft. in length, and 68ft. in width. The single lamp hung from the roof at a height of about 50ft. from the floor lighted brilliantly every part of this large building (except, of course, where shadows were thrown by pillars under galleries) at an expenditure of about one horse-power in the lamp itself.

The lamp was also exhibited at a private entertainment given by Sir William Thomson to his laboratory corps and to other students of the Natural Philosophy Class. It was hung from the staircase above the entrance hall of Sir William's house, and proved itself, by its clear and steady light, admirably adapted for lighting the halls and passages, and even the large rooms of a private house.

STUDENTS' COLUMNS.

CITY AND GUILDS EXAMINATIONS.

The solutions in this number are solutions to some of the "*Honours*" questions in the paper hitherto considered, by E. C. Rimington, Esq. (School of Electrical Engineering), 12, Princes-street, Regent-street.

20. Explain how the very high potential necessary for obtaining economic electric transmission of power can be practically employed by the use of secondary batteries.

Ans. By employing this high potential to charge secondary batteries, arranged in series, so that their back E.M.F. is nearly equal to that at the ends of the line. When charged, the batteries are disconnected and arranged, a certain number in series, and a certain number in multiple arc, so as to obtain the E.M.F. required to work the lamps or motors, and are thus discharged, fresh batteries being put in their places to be charged.

21. What are the advantages of electric railways over the present system of railway propulsion?

Ans. The chief advantage of electric railways over ordinary locomotives is to be derived from the fact that very large stationary engines can be worked with far greater economy as regards fuel than locomotives can be, because, in the case of the latter, economy in fuel has to be sacrificed to a very great extent to size and lightness in construction. Another advantage is as regards weight, as the motor required to propel a railway carriage may be of small dimensions and weight. Further, the permanent way and bridges, &c., may be lighter and, therefore, cheaper.

Errata.—In answer to question (16), page 350

$$\therefore \frac{w}{e} = \frac{E\,(E - e)}{746\,R} \text{ should read } \therefore \frac{w\,E}{e} = \frac{E\,(E-e)}{746\,R},$$

and near the bottom of the page

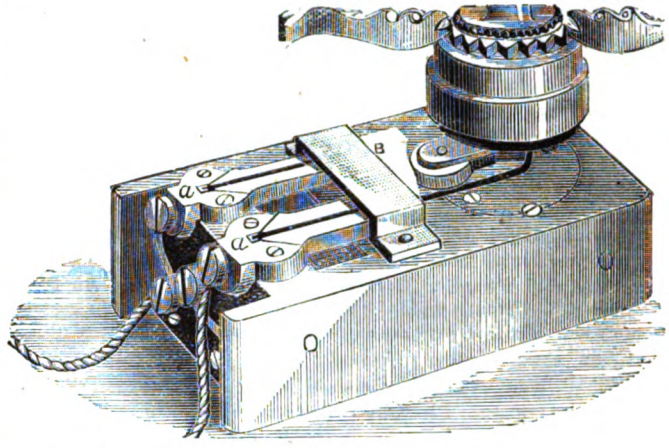
$$H = \frac{w\,(E \mp \sqrt{E^2 - 2984\,w\,R})^2}{2984}$$

should be

$$H = \frac{w\,(E \mp \sqrt{E^2 - 2984\,w\,R})^2}{2984\,R}.$$

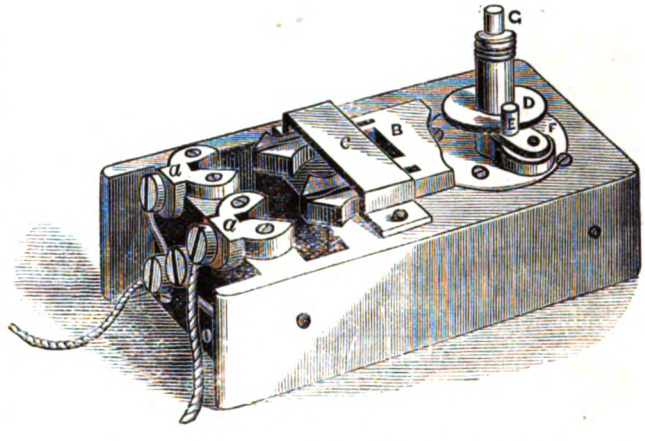
BAYLEY'S PATENT SWITCH FOR ELECTRIC LIGHT AND OTHER PURPOSES.

This switch consists of two strong gun metal segment terminals with V-shaped receiving sections, *a a* (Fig. 1), also a bolt, B, of gun metal, the contact faces of which are carefully shaped and fitted to the contact faces of the terminals. The



Bayley's Switch, with outer case removed.—Circuit Closed.

contact portions of the bolt are split, and strong steel springs securely fixed in them, necessitating perfect electrical contact when the circuit is closed; C is a guide bridge, guiding the bolt B home; G is a centre spindle pin, with a movable flange, D. Attached to this flange is a lever pin, E, to which is also attached a steel roller, F. On the top of G is a metal segment, with a play cavity on one side securely fixed into an insulated segment, covered with a metal cap that carries the ornamental lever handle. When the handle is turned it causes the roller to press the bolt B (Fig. 2) into contact with the terminals *a a*, the steel springs in the bolt plugs always causing good electrical contact. The drawback spring is



Bayley's Switch, showing details of handle.—Circuit Open.

buried in the insulite material, on which the whole of the work is mounted. The great advantage of this switch is that it is beyond the operator's control when shutting off the lights to make arc, or, rather, the arc is reduced to a minimum. The moment the roller passes the centre of the bolt it flies completely out of circuit, its arcing is thereby reduced to the lowest possible point. A switch sent us for examination was designed to control from 60 to 80 lamps of 16 candles each. A safety fuse wire is inserted, S shape, between two terminals, as shown. These switches can be made in all sizes and various ornamental covers. The workmanship in the one under our notice is excellent. The switch is enclosed in a neat brass case.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

ANSWERS TO CORRESPONDENTS.

LEIDHBOURNE.—*We have no objection to publish your letter. We think the suggestion would hardly meet with general response. If we mistake not the idea has been mooted several times, and was found to be impracticable. Our opinion is, perhaps, not worth much; but it is that there does not exist in your profession a sufficient number of able writers, even if there were readers to be found, to command success.*

A WELL WISHER.—*The name you mention is, we think, not Albert but Albright, and the Company the Swan Company, whose address is St. Mildred's-court, Poultry, E.C. It would be preferable for you to write to that address than for us to insert your letter.*

C. A. S.—*You had better communicate with Messrs. Elliott Brothers,* 449, *Strand, W.C.*

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TELEGRAPH TARIFFS.

In the course of the speech with which he introduced the Budget Mr. Childers announced that he had set aside £170,000 out of this year's surplus to meet the deficit consequent upon the adoption of sixpenny telegrams. Following close on the heels of the peculiar division which took place the week before, and coupled with his own expression of opinion on that occasion, the announcement can only be regarded as another example of immediate and unconditional surrender to clamour—the clamour in this instance, as we pointed out last week, being of the most selfish and least public-spirited sort. The incident is highly significant seeing that the money cannot possibly be needed for the present year. There can be no sixpenny telegrams until the Telegraph Department is able to deal with them—not until additional wires, more apparatus, and increased staff are ready for use. Money will be needed, but it will be in the shape of additional capital, not to meet a deficit in revenue. It has been the fashion of late years to overtax and underestimate in order to create the semblance of a surplus at the end of a financial year. The new Chancellor of the Exchequer seems to be following that very effective though somewhat oppressive line of policy. He will probably have his £170,000 intact at the end of the year; meanwhile, the taxpayer has to pay for its being "set aside" in anticipation of a deficit that is not likely to occur. Members "below the gangway" applaud, however, and it is a great point to get applause from that quarter; so we are to have sixpenny telegrams, and a consequent cessation of complaints against the Treasury.

That being the case, somebody will have to determine what the sixpenny telegram is to be. In this relation we should have liked to know on what bases the calculations referred to by the Postmaster-General were made by those officials whose estimates of deficiency consequent on a reduced tariff differed so very widely. Nearly everything depends on the size of the telegram. Public opinion will no doubt be sounded during the next few months before this point is decided. At present we can only be certain on two points—first, that there is some conflict of opinion between the parties who are likely to be the final arbiters inside and outside the House of Commons; but, secondly, that the sum named above is in any case supposed to be sufficient to cover the first year's loss. That sum being fixed upon, it is probable the tariff finally recommended by the Telegraph Department will be such as they anticipate will be justified by the provision. This is unfortunate, for it may prevent the tariff being framed on equitable and common-sense principles. Nevertheless, while the subject is fresh in the public mind we will venture to offer a few remarks on the sound principles which ought to regulate all tariffs.

First, as to uniformity. This is purely a matter of public convenience, and cannot apply to countries of any considerable area. What seems just and natural for small kingdoms like Belgium, Holland, and even Great Britain would be absurd, say, for the Russian dominions. Conversely, the argument for lower tariffs on town telegrams holds good where the national territory is large, but the towns comparatively small. Were it not for London being practically a county in itself, indeed for telegraphic purposes as extensive as some European States, a local tariff might be practicable in this country. But we must look at the facts, and the facts are against any generalisation applicable to all countries and towns alike.

These remarks apply equally to the word tariff. Its merit as a uniform system extends so far, and no farther, than the geographical facts will permit. It is roughly based on distance, and, to the extent that it taxes the sender for the exact number of words he requires to be signalled, it is equitable; but it would be easy to point to anomalies which, on the assumption that uniformity is the public's by right, are quite indefensible. The telegraphing public have a right to just so much simplicity and uniformity as the circumstances will warrant, and no more. The word tariff for international telegraphy happens to be workable on other grounds. The addresses are very short, for the simple reason that international telegraphy is chiefly confined to the commercial community, whose places of business are well known. For inland telegraphy this word tariff, which is theoretically the most equitable, would be unfair to the general public, whose addresses are necessarily longer than those of business men. It would lead to curtailment of addresses in order to save

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expense, if the telegram, as a whole, were charged by the word; and it would also put the carriers to a good deal of extra trouble and expense for delivery.

The uniformity, therefore, at once practicable and equitable for a country like this, would consist of a fixed price for any number of words not exceeding a certain limit. Its next stage would depend so much upon the initial limit and upon the mode of counting, that we need not discuss it until these points are settled. The main thing to be done is to fix the limit; but this cannot be fixed until the vexed question of free addresses is disposed of. If the agitators for cheap telegrams had been sincere or disinterested they would have demolished the existing system long ago. Of all the anomalies in the world-wide range of telegraphy, none is so monstrous and so utterly indefensible as that which Mr. Fawcett has mildly described as "wasteful." He might have said ruinous without much exaggeration. It concedes to the public the right to send any number of words for nothing, providing they come under the heading of addresses. A great opportunity of remedying this abuse was lost when the telegraphs were acquired by the State; now again an opportunity has arisen, and if advantage be not taken of it, there will never occur another. We shall probably return to the discussion of this part of the question before it is finally settled; but for the present we may be content to point out to the business classes, whom, after all, this reduction of tariff will chiefly affect, that their interests are decidedly threatened by the continuance of free addresses. The initial limit for the chargeable text must necessarily be low if addresses are to go free; if they were charged for, as they ought to be, the text could be proportionately expanded, and the text is the main thing for commercial men.

We shall be agreeably surprised if the price for Press messages under the new tariff is not made the subject of question and discussion before this Session is over. It is notorious that the Press is served on exceedingly liberal terms at present. But the Press is apt to set its own estimate upon its title to consideration, and when we see the newspapers unanimously advocating a measure the true bearings of which it is plain they know nothing about, we may safely infer that they are saying one word for the public and two for themselves. Yet there is no logical justification for treating them differently from the general public. Night messages ought by rights to be charged for at extra rates; but, if the reverse of this proposition is to hold good on the ground that, night service being unavoidable, the wires may as well be earning money, then it follows that the public as well as the Press should have the benefit of cheaper rates during the slack hours, and the rate should be substantially the same for both. This, at all events, is the equitable view to take of the case. If, in actual practice, it is found that Press telegrams are remunerative at a lower figure than are ordinary messages, then the Press is entitled to an abatement. But we fail to see how this newly-proposed reduction on public telegrams will entitle the Press to a further reduction on theirs; on the contrary, the large increase in the number of public telegrams that may be reasonably expected to be forwarded after business hours under the new tariff seems to point in the opposite direction.

Western and Brazilian Telegraph Company.—The traffic receipts of this company for the week ending 6th April, 1883, were £2,342, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

OURSELVES.

The annual social gathering of the proprietors and contributors of *The Electrician* was held at the Criterion on Monday, April 9, under the presidency of J. Pender, Esq., M.P., when an excellent dinner was provided by Messrs. Spiers and Pond. Several well-known contributors were unavoidably absent, and we missed some transatlantic friends who have in previous years favoured us with their presence. Sir J. Anderson was vice-chairman, and the following gentlemen were around the table:—W. C. Cartwright, Esq., M.P.; Mr. C. H. B. Patey, Mr. E. Graves, Mr. W. H. Preece, Mr. Albright, Mr. K. Anderson, Mr. W. W. Beaumont, Mr. Shelford Bidwell, Mr. C. H. W. Biggs, Mr. T. H. Blakesley, Mr. R. E. Crompton, Mr. Brockwell Dalton, Mr. J. J. Fahie, Mr. D. G. FitzGerald, Mr. L. Florsheim, Professor W. Garnett, Professor D. Hughes, Mr. E. H. Johnson, Mr. G. Kapp, Mr. J. Laister, Mr. J. F. Moulton, Mr. W. H. Parker, Mr. J. Pender, jun.; Mr. E. C. Rimington, Mr. H. Saunders, Mr. Willoughby Smith, Mr. J. T. Sprague, Mr. J. H. Swan, and Mr. F. C. Webb.

During the course of the evening the chairman remarked that, although this might well be termed an electrical age, he was still of opinion that the applications of electricity were only in their infancy, and from experience he could tell the scientific men present that the monied interests would always be ready and willing to hold out a helping hand towards any developments that showed great promise, and he entertained the idea that at no very remote future the Society of Telegraph Engineers ought to rank as high in the opinion of the world as the Institution of Civil Engineers does now. Sir J. Anderson, in reply to the toast of "*The Electrician*," pointed out that the intention of the proprietors of the paper was that it should be the best paper on its special subject that could be found in this or any other country.

CORRESPONDENCE.

UNIPOLAR DYNAMO MACHINES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: In your issue of March 31 you gave an account of Ball's so-called "unipolar" dynamo, and also printed a report upon one of these machines now being exhibited in London.

My attention was some weeks ago drawn to this dynamo, and the conclusions I then formed are still unaltered, viz., that it had no points sufficiently good to cause an intending user of electric force or energy to buy it in preference to many other dynamos now in the market, letting alone the question of its not being as good as some others.

Most *thinking* electricians will regret that this report should have been published, as it unintentionally misleads the public, proper instruments and apparatus not having been provided, as is proved by the following quotation from the report:—

"The speed of the machine was not so regular as could have been desired, and the Morin dynamometer by which the power given to the dynamo was measured would have worked steadier had it been run quicker and with a heavier load."

I thus find some essential points unreliable by their inaccuracy when I wish to test the real value of a dynamo, viz., the relation of the amount of useful work in outer circuit to that employed in driving the dynamo.

A contemporary points out that this dynamo by this report appears to return 5 or 6 per cent. more useful work than the best of the various dynamos of the well-known maker tested by the committee at the late Electric Exhibition at Paris.

Now, as the speed and dynamometer readings were so inaccurate and irregular, these results cannot be accepted as satisfactory or accurate.

Another point. The report states 3·92 h.-p. was accounted for in the outer circuit, and, further, in the mean result,

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accounted for in one lamp is 0·75 h.-p. (or, more exact, 0·74), thus giving as the mean result for the six lamps 4·48 h.-p. in the outer circuit, leaving out any work done in the connecting wires, or 0·56 h.-p. in excess of his previous total mean h.-p., viz., 3·92.

If I accept this 4·48 h.-p. as a correct mean, then the proportion of work accounted for electrically must be $\frac{4·48 + 1·35}{5·68}$ $= \frac{5·83}{5·63}$, or over cent. per cent., which is impossible, or, leaving out the odd 0·20 as sundries or inaccuracies, the only explanation can be is that no so-called Foucault's currents are produced, a point even the inventor of the dynamo will hardly claim.

I am aware in making the above remarks that the report clearly states that the figures relate to only one lamp, but inasmuch as the candle-power given is that of this lamp, the results published tend to mislead the public by inference that the other lamps are equal to this one, which cannot be, as shown. The diagram showing the winding and connection of the dynamo is incorrect, for how a north-pole piece can be produced in the centre of a covered bar when the current is flowing in the same direction in the portions on either side of the pole piece is extraordinary.

But as this may be only a draughtsman's error, I look to the theory of the neutral pole piece and the unipolarity.

Now, when the pole-piece is throwing off magnetic lines of force, these must necessarily be attracted by any stationary piece of iron near, and if this iron is neutral as far as the circulating currents in the field magnets are concerned of which it is a part, it still must have some polarity given to it by induction from being in the neighbourhood of the active armature, and when it is so induced the previous state of neutrality must be considerably modified, and the iron, now a pole piece, will, in consequence, react upon the lines of force from the other active pole piece. This neutral iron is thus converted into a *supplementary pole piece* by accident, though not design.

This *supplementary pole piece* at once cuts away the ground for calling this dynamo a unipolar one, as far as the fields are concerned, and, as far as I am informed, Mr. Ball does not claim unipolarity for his armature.

There are many other points, had I dared trespass upon your space, I should have liked to have drawn attention to, for I feel very strongly that more difficulties should not be placed in the progress of electric distribution than there are at present by the promulgation of misleading statements obtained from unsatisfactory data.

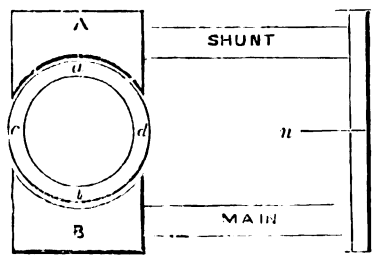
I think, therefore, that Mr. C. W. Raymond should, in the interests of Mr. Ball, at once have a fresh report made, and should before doing so see that the speed of rotation of the dynamo could be kept constant, and the dynamometer working so as to give absolutely correct results.—Yours, &c.,

E. E. A.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The recent description of Mr. Ball's dynamo machine has given rise to considerable comment as to the use of one inducing pole in magneto-electric machines, and it is somewhat surprising to learn that the capability of inducing a current under the condition is thought novel. Perhaps the false notion that in a Gramme ring the inside wires were of *nil* effect in producing electromotive force may have retarded the observation by preventing the true action (or perhaps I should say the action as *experimentally* determined) of the Gramme ring obtaining general support. If we look upon the Gramme ring as a particular form of electro-magnet a great deal of the mystery surrounding it disappears, and that this is the true function I hope the following observations, obtained in experiment, may at least help to prove. Let the diagram represent a Gramme ring revolving between the poles of an electro-magnet. In the particular case of Mr. Ball's dynamo we may remove one of these poles, because his ring is set between, say, A and the neutral line *n* of the magnetic arrangement; but I will consider the use of one pole as it occurs to a greater or less degree in my self-regulating machines, after pointing out an extension of the use of one pole.

If A be made a north pole, then *a* will become south by induction, and *b* north. *If the mass of iron in the ring is not too great and yet sufficient*, the neutral line or brush-diameter will be at *c d*. *If the mass is insufficient, or is too small in section with relation to its length (around the circle), then the points c and d will approach a.* These conditions have long been known to me experimentally. I am considering B to be removed or to be inoperative. But suppose that B as well as A be made a N pole, then *c* and *d* become south by induction, and we have to put our brushes at points intermediate to *a* and *d*, *d* and *b*, *b* and *c*, *c* and *a*, but the sign of the brush (+) is no longer alternate counted round the ring. This extension of Mr. Ball's idea has, I believe, been patented, and is no more a bi-polar machine than is that due to Mr. Ball's "unipolar."



But these induced poles are not capable, in my experience, of producing the same electromotive force, for the same speed and length of wire.

As to the question of the action of the Gramme ring, let A be a N-pole, and B a S-pole, and let the iron of the ring be separated into parts *a*, *d*, *b*, *c*, *a*, so that each part is magnetically insulate from the next parts whilst the wire is continuous—easily carried into effect by composing the ring of separable bobbins joined together with strips of brass or of iron, as may be desired, at the junctures, or as in the case of the actual experiment connected by either brass or iron bolts, the wire on the ring remaining unaltered. Now, when the brass bolts are in, there is *no* electromotive force of any practical value, but when the iron bolts are in the magnetism and the electromotive force are fully developed. Whatever may be due to the windings of the wire is purely a matter of theory, for with the same mass of iron in detached pieces in the ring, the incompletion of the electro-magnetic system (although the "magnetic screen" is still there) is productive of a *nil* inductive result. Now, whilst the brass bolts are in, if a bar magnet be approached so as to bring about a completion of the electro-magnetic system in one of the segments, *e.g.*, supposing A a N-pole, let the S-pole of the bar magnet be brought to the point between *a* and *d* corresponding to one of the separable lengths, then an appreciable E.M.F. is immediately manifest. Of course the bolts must afford a good and sufficient surface for the magnetic contact between the separable parts. I contend that if, as certainly appears, the action of the Gramme ring is mainly that of an electro-magnetic system, then the inner wire is as efficacious as the outer wire. That there *is* an E.M.F. due only to the outer wire is undoubted, but it is very small.

Mr. Oliver Heaviside, I was glad to observe in a recent number of this journal, gave his adhesion to the equal efficacy of the inner wire of the Gramme ring; and I think it can be proved also from Du Moncel's simple yet elaborate experiments.

I have remarked that the effect of using only one inducing pole has been known to me for a long time; it is one of the means by which in larger sizes of my self-regulating machines I obtain a thorough control of the circuit. From time to time I have been somewhat amused by the so-called mathematical proofs offered of the necessity of maintaining a constant electromotive force in a self-regulating system *at the terminals of the machine*. Had the worthies who are so ready to instruct us ever put their theories to the test of

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practice, they would have found that it is the difference of potentials at the far end (of a multiple arc) circuit that must be maintained constant. To adopt the argument *ad hominem*, let G be the generating station, H the next house, and I further down the street:—

G . . . . H . . . . I.

Now we maintain a very constant difference of potential at G, but if H plays pranks I will know all about it. For instance, let, in a lighting circuit, H adopt his own lamps, of the same number may be, but of half the resistance of I's, then I will soon know how much a constant difference of potential at G is worth; or, to proceed to limits, let H short circuit. Then, of course, I has no current, whether of gas, water, or electricity. The practical engineer will tell us the constant head must be at the *end* of the main.

How H can be prevented taking more current than he contracts for is not the present point; but it can be done easily and without going farther than the generating machine, and I shall be glad to enter on the subject in your journal if you can find room for my remarks at a more opportune time. I was about to say that, as in the diagram above, the polarity A being provided by the shunt circuit, we can have an initial E.M.F. of any power we choose to arrange, without any influence from B (except from induction). *Now we may light a certain number of lamps, using* A *pole only as in a shunt machine;* or we may begin to pass current through B, and use the whole self-regulating system. In the first place, we start with a close approximation to a so-called "unipolar" machine, but with the advantage over a self-regulating machine with the shunt and main magnets on the same cores that the earlier lamps are better under control and are never over-forced. If the main circuit becomes of a lower resistance than is provided for in normal running the machine comes again into action with a single pole, that due to only the main circuit at the limit when the resistance is too low to maintain a charging current in the shunt-magnets. And although the main-circuit magnet is superexcited, its pole alone is acting, and the electromotive force is not increased. The range of self-regulation can be thus much extended, and render large machines as controllable as small.—Yours, &c., PAGET HIGGS.

WEDGWOOD'S TELEGRAPH.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Among the early proposed electric telegraphs it appears to me that that of Ralph Wedgwood, the inventor of the carbonised manifold paper so extensively employed for copying letters, has hardly received the attention it deserves. The account of his telegraph appears at the end of a volume entitled "The Book of Remembrance," by R Wedgwood, London, 1814, and forms part of an appendix, in which he describes the carbon paper. He says:—"*The Fulguri Polygraph*, which admits of writing in several distant places at one and the same time, and by the agency of two persons only.

"This invention is founded on the capacity of electricity to produce motion in the act of acquiring an equilibrium, which motion, by the aid of machinery, is made to distribute matter at the extremities of any given course. And the matter so distributed being variously modified in correspondence with the letters of the alphabet, and communicable in rapid succession at the will of the operator, it is obvious that writing at immense distances hereby becomes practicable; and further, as lines of communication can be multiplied from any given point, and those lines affected by one and the same application of the electric matter, it is evident from hence also that *fac-similes* of a despatch, written as for instance in London, may with facility be written also in Plymouth, Dover, Hull, Leith, Liverpool, and Bristol, or any other place, by the same person, and by one and the same act. Whilst this invention proposes to remove the usual impediments and imperfections of telegraphs, it gives the rapidity of lightning to correspondence *when* and *wherever* we wish, and renders *null* the *principal disadvantages* of *distance* to *correspondents*. Independent of the advantages which this invention offers to Government, it is also susceptible of much utility to the public at large; inasmuch as the offices which might be constructed for the purposes of this invention might be let to individuals by the hour for private uses, by which means the machinery might be at all times fully occupied; and the private uses which could thus be made of this invention might be applied towards refunding the expenses of the institution, and also for increasing the revenue. Innumerable are the instances wherein such an invention may be beneficially applied in this country, more especially at a time when her distinguished situation in the political, commercial, and moral world has made her the central point of nations and the great bond of their union. To the seat of her government, therefore, it must be highly desirable to effect the *most speedy and certain communication* from every quarter of the world, whilst it would at any moment there concentrate instantaneous intelligence of the situation of each and every principal part of the nation, as well as of each and every branch of its various departments."

—Yours, &c., LATIMER CLARK.

April 9, 1883.

SAFE CURRENT THROUGH COPPER WIRE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: With reference to the letter of Mr. H. Cleland Heywood in the last number of *The Electrician* (page 495), on the subject of the current of electricity which may be safely transmitted through wires of various sizes, we enclose you a table of sizes and weights, calculated from the formula given, which may prove useful. We would at the same time remark that the table is intended for use in the hot climate of India, and is applicable to insulated wires, which may, as in our experiments, be surrounded by dry wood, sand, or other imperfectly conducting material. In this country similar wires, especially if exposed to radiation, might be trusted to carry considerably larger currents.

There are two clerical inaccuracies in the formulæ as given, which require correction, viz:—

$$W = w\left(\frac{m}{n}\right)\frac{4}{3} \text{ should read } W = w\left(\frac{m}{n}\right)^{\frac{4}{3}}$$

$$W - A \times 10{\cdot}75\sqrt{H} \text{ should read } W = A \times 10{\cdot}75\sqrt{H}.$$

TABLE showing current which may be safely carried by wires of various sizes.

B.W.G. No.	Diameter.	Weight per Mile.	Amperes.	Lbs. per Ampere.
	Mils.	Lbs.		Lbs.
22	28	12·4	2·33	5·32
21	32	16·2	2·84	5·70
20	35	19·5	3·27	6·00
19	42	28·0	4·3	6·5
18	49	38·1	5·4	7·0
17	58	53·3	6·9	7·7
16	65	67·1	8·3	8·1
15	72	82·5	9·6	8·6
14	83	109·5	11·9	9·1
13	95	143·0	14·56	10·0

Yours &c., CLARK, FORDE AND TAYLOR.

7, Pope's Head-alley, Lombard-street, E.C.,
April 10th, 1883.

CONNECTING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your impression of March 31 (p. 473), I observe a sketch and description of a new (?) method of connecting up the main conductors with the different branches. I enclose herewith a sketch of a somewhat similar, though more perfect, arrangement for the same object, which was designed some time ago by our head elec-

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trician, Mr. Walter Kirk, for an installation of 80 lights. You will see by the sketch that this arrangement is considerably more compact than the Edison Company's, and has the additional advantage of containing a safety fuse (very easily renewable in case of fusion) to each branch.—Yours, &c., W. Bridges Adams.

The following explains the diagram:—

In Fig. 1, B B is a +, and B′ B′ a — main connecting bar; C C branch connections, each fitted with a fuse; W and W′

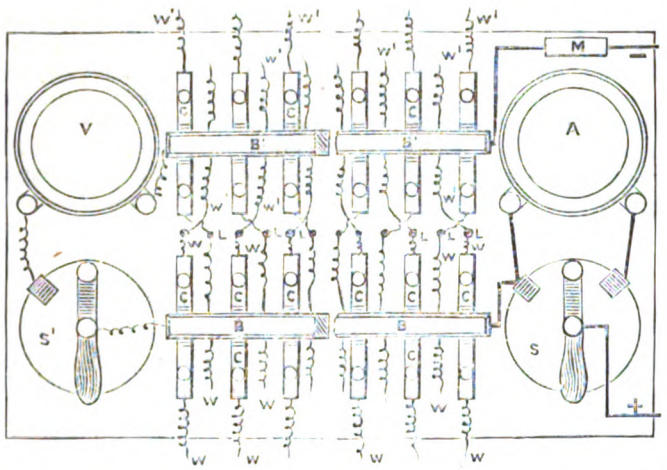


Fig. 1.—Kirk's Current Distributor. Plan View. V stands for volts, A for amperes.

are branch wires, L L lamps, S a two-way switch, either to break circuit, put in, or short circuit ammeter; S′ a switch for voltmeter.

The current enters by + wire, through S, passing either through ammeter or direct to B, then divides through branch circuits by wires, W W′, and reaching B′, finally goes by main fuse, M, to — wire.

Fig. 2 is a section through one of the bars B or B′, showing fuse, H, bent over a strip of mica, M′; S a metallic spring kept in contact with H by the head of the contact screw,

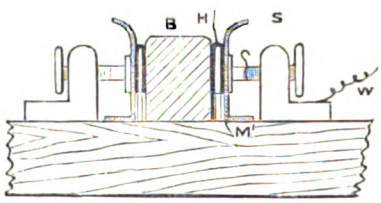


Fig. 2.—Kirk's Current Distributor. Section through one of the Bars, B or B′, showing Fuse.

which passes through branch wire terminal W. By screwing back on the terminal (thereby breaking that branch circuit), an exploded fuse may easily be replaced between B and S without fear of sparking, and then the circuit made by screwing back the screw.

EARTH CURRENTS.

TO THE EDITOR OF THE ELECTRICIAN.

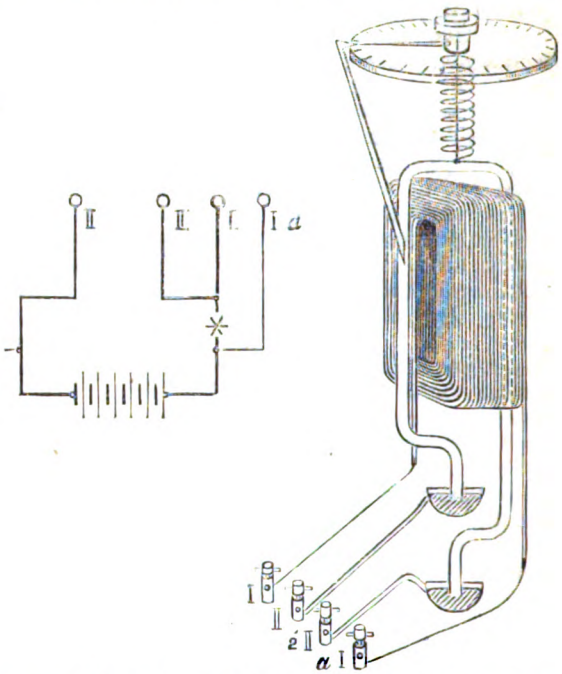
Sir: On the 15th March we had rather strong earth currents (at first mistaken for lightning) on the line between here and Teheran, and at 4 a.m. on the 16th a severe shock of earthquake occurred. Direction S.E. to N.W., lasting about one second and a half. It commenced with a subterraneous rumbling noise, and finished with two sharp jerks. I have not heard of any damage to life or property, but a dumb bell, weighing 8lb., which was lying on the floor in my bed room, was rolled several feet across the carpet and rebounded against a door with a loud report.—Yours, &c.,

J. Stanfield, C.C.

Indo-European Telegraph Company,
Tauris, Persia, March 20.

SIEMENS'S WATT METER.

It will remembered that at the late meeting of the British Association at Southampton Dr. Siemens, F.R.S., president of the association, suggested two new units, the weber and the watt, the latter being the unit for power, and in a more recent paper before the Institution of Civil Engineers Dr. Siemens described a watt meter. The accompanying diagrams will explain this instrument, which to look at is very similar to the well-known Siemens electro-dynamometer. The watt meter consists of a fixed coil of many convolutions of fine German silver wire, and, consequently, of very high resistance. The terminals are attached to the binding screws marked I and I_a in the figure. A second coil, consisting of a single convolution of thick copper wire, is hung by a thread from a torsion head, supported by the frame of the instrument. The extremities of the coil are immersed in two cups of mercury connected with the binding



Siemens' Watt Meter and Method of Connecting it up in a Circuit.

screws II and II_a. Attached to the thick wire is a pointer, showing on the scale when the coil is deflected from its zero position. A second pointer is attached to the torsion head, and reads the torsion in degrees. It is clear that if currents be passed through the two coils the thick coil will be deflected, but can be brought back to its initial position by increasing the torsion of the spring. The angle of torsion will then measure the product of the intensities of the currents. The effect of the earth's magnetism is eliminated by this null method of using the instrument. To measure the power absorbed, say in an arc light, the fine wire coil must be connected as a shunt to the arc, while the main current passes through the thick wire. The current in the fine wire will then be proportional to the difference of potential between the carbons; consequently, the deflection will measure the product of the electromotive force and current, and hence the power absorbed in the arc. A table is provided with each instrument showing the horse-power and watts, and corresponding to each five degrees of deflection of the pointer.

Telephonic Communication in Birmingham.—The National Telephone Company have arranged to provide the subscribers to the Birmingham Central Exchange with a continuous day and night service, Sundays included, without extra charge. No doubt this will be very largely appreciated, and equally, no doubt, the company will reap the benefit of their concession.

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THE LIGHTING OF THE UNION SOCIETY'S BUILDINGS, OXFORD.

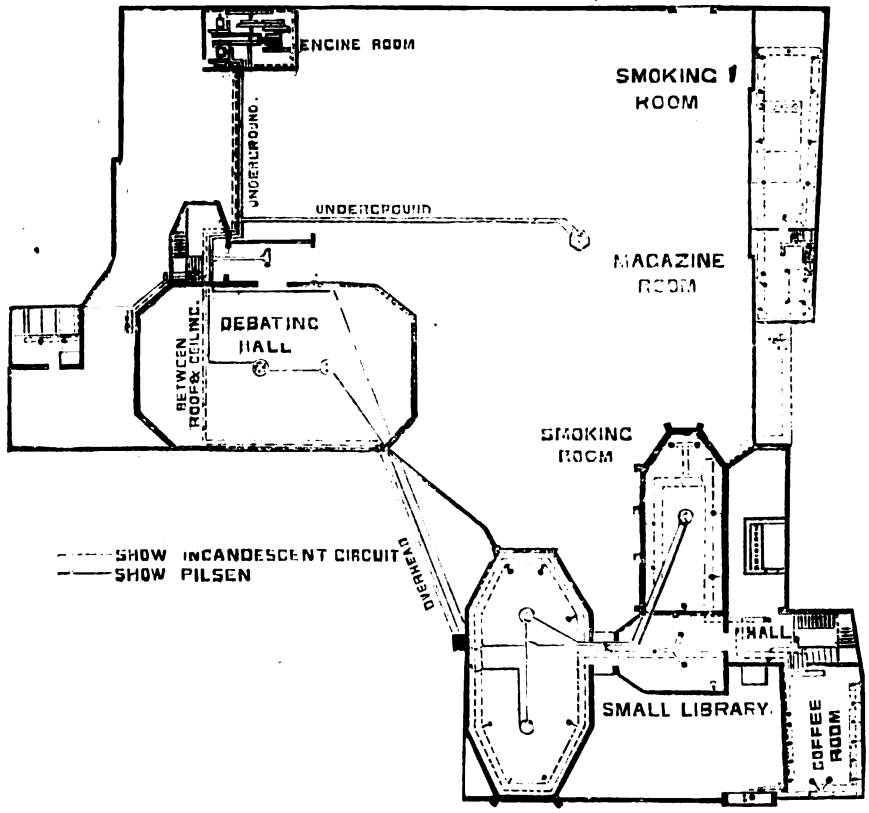
In a recent note we called attention to the fact that the Pilsen-Joel and General Electric Light Company had carried out the lighting of the above buildings by a combination of arc and incandescent lamps. Through the courtesy of the company we are now able to give an illustration of the method of running the lamps with a plan of the buildings lighted. The lamps are distributed throughout the libraries, debating hall, writing room, offices, &c. It appears that during last year's exhibition at the Crystal Palace, a committee from the Union Society specially visited the Palace with a view to adopting the electric light in their buildings, and were commissioned to report upon the best system for the purpose. The result of this visit was the selection of the Pilsen arc lamp for the large halls, as being the steadiest and least noisy of that class, and the Swan incandescent lamps for the small rooms, &c.

The following details will give some idea of the extent of this installation:—

The debating hall, whose area is 70ft. by 40ft., was previously lit with two sunlights, each consisting of 49 gas jets of eight candle-power each, giving a total light of 784 candles, at an elevation of 30ft. These have been replaced by two Pilsen lamps at the same elevation, each of 2,000 candle-power. Fifty per cent. of this light is lost, owing to the opal globes used to soften the light, so that the useful light given out is a total of 2,000 candles, or almost three times that given by the discarded gas.

The lamps are lowered for trimming and cleansing by a special arrangement of cords passing over drums fitted above the ceiling, and which are so arranged that the cable is pulled up simultaneously with the lamps, thus avoiding the disfiguring festoons usually employed. In the library, which is a handsome hall, 50ft. high by 30ft. broad and 70ft. long, are hung two Pilsen lamps to replace a large gaselier of 54 jets and 10 single lights under the gallery. The lamps are suspended about 25ft. from the floor, and their weight is counterbalanced by cast-iron counterweights, which are suspended by cords passing over drums fixed above the ceiling, and over which the cable is made to pass automatically. Under the gallery are distributed nine incandescent lamps, each of 20 candle-power, to relieve the shadows cast by the gallery; these, however, are, it is stated, not required.

The Pilsen lamps are identical with those in the debating hall, so that the total light given out is 2,180 candle-power, as compared with 64 gas jets of 10 candle-power, or 640 candles. Since the electric light has been started in this room there has been a marked difference in the condition of the books, especially those near the roof, owing to the total absence of those injurious elements which render gas so objectionable. The library walls have been decorated by old students of the university with paintings illustrating the Arthurian legends, and these are now seen to much greater advantage than previously. The next room in rotation is the writing room, which used to be lighted by four gaseliers having a total number of fifty gas jets, but by placing the electric lamps in more advantageous positions they light up the writing tables more efficiently with fourteen incandescent lamps of twenty candle-power each.



Plan of the Pilsen and General Co.'s Installation at the Oxford Union Society's Buildings. Thick lines represent the Arc Circuit, dotted lines the Incandescent Circuit.

The smoking room, which is immediately above the writing room, is furnished with one Pilsen lamp and seven incandescent lamps, to replace one gaselier of 54 jets and eight candle-power, and ten single lights, so that the light is about doubled. In the other rooms, entrance halls, staircases, &c., incandescent lamps are entirely used, and in most instances simply replace the gas jets.

The incandescent lamps are joined up in multiple series of two, so that in case of one lamp short circuiting the other in the same series serves as a safety plug, and in practice this is found to be more to be depended upon than the ordinary lead fuses which are usually employed. Fusible plugs are, however, fitted on all the main branches. The incandescent lamps are worked by a thick wire quantity machine, and the Pilsen lamps by a No. 6 Pilsen dynamo machine. The motive power is supplied by a 12 horse-power nominal Crossley gas engine, specially balanced. The power is transmitted through a 3in. countershaft, on which is keyed a 5ft. fly-wheel weigh-

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ing 6cwt. Both dynamos have also balance wheels fixed to them, so that by these precautions an absolutely steady current is obtained, notwithstanding the unequal motions incidental to gas engines.

The engine room is a neat brick building, 24ft. long, 12ft. wide, and 10ft. to eaves, and is in the grounds, very near to the main buildings, and close to the adjoining street, so that it became of importance that the noise of the engine should not disturb the inhabitants. To accomplish this three exhaust boxes and one large silencing chamber, supplied by Crossley Brothers, are used, and the result has been quite satisfactory.

The accompanying sketch shows the general arrangements of the engine house and leads. The dotted lines and circles show the incandescent circuit and lamps, and the thick lines the Pilsen arc lamps. It also shows a Pilsen lamp in the garden suspended from an iron pole, which has a fine effect on the trees and grass. Formerly there was no light at all in the garden.

A summary of the installation shows:—For the electric light: Six Pilsen arc lamps of 1,000 candle-power actual, equal to 6,000 candles; 109 incandescent lamps of 20 candle-power, equal to 2,180 candles, or a total of 8,180 candle-power against 353 gas jets formerly used, giving, say 10 candle-power each, or a total of 3,530 candles. Careful readings have been taken every night of the gas consumed by the engine, and estimating as nearly as possible the number of hours that the light will be used during the year, and taking gas at 2s. 10d. per 1,000ft., the price in Oxford, it was found that the annual cost of gas (for engine) will be about £70. To this must be added about £120 for carbons and attendant's wages and other expenses; thus we get a total of £190 per annum. The gas bill paid by the society has been £250 per annum, so this leaves a margin for depreciation of electric plant.

Assuming that the cost of the electric light, with depreciation and interest, is the same as the cost of gas, the difference in favour of the electric light is very remarkable, giving nearly three times the light with all the advantages of pure air and decreased expense in redecorating, whilst the many valuable books in the society's libraries are preserved, and for fine art studies the colours can be seen as well by night as by day. This installation is in every way noteworthy as indicating what can practically be done with electric light. The work has been carried out by the Pilsen Company, under the superintendence of Mr. D. C. Smith, one of the company's assistant engineers, who may be congratulated on the successful result of his labours.

LITERATURE.

Electric Illumination. *Engineering* Series. Edited by James Dredge.

(continued from page 477.)

The chapter on "Magneto and Dynamic Generators" deals with the history and development of the modern machines from the first experiment of Faraday in 1831, and the earliest mechanical application of it by Pixii, in which, rough as it was, all the essential elements of the subject are to be found. An excellent description of the machine of Elias is given, with good illustrations, but in this description appears very plainly a disposition, which runs through the whole chapter, to dwell upon earlier anticipations and merely structural resemblances, to the disadvantage of late inventors who have taken up the subject. This machine it is said, "may be considered as a prototype of the Gramme machine," and a striking resemblance is said to exist between the one invention and the other, although the Elias was devised solely as a motor. A very slight examination of the operation of the machine will show that the resemblance is much like the proverbial resemblance between chalk and cheese. It is true that the Elias armature is a ring, as is the Gramme, but the Gramme is a true ring continuous throughout, involving a definite principle. The Elias ring is merely a mechanical arrangement of independent segments; it, in fact, is the prototype of the De Meritens ring. On the other hand, the Elias machine is the prototype of several other later machines in which the apparent resemblance is not to be seen. Its action is the same as that of Lontin and of Gramme for obtaining alternating currents, although in both of these the ring series of magnetic poles is exchanged for a radial system. In fact, the Elias machine is a regular alternating one, in which a system of electro-magnets arranged for convenience in a ring travels within a similar system, with an equal number of opposed poles maintained by a constant current.

The same disposition is shown in the remark on the invention of some unknown patentee in 1858:—"Anticipating by eight years the grand discoveries of Siemens, Wheatstone, and Varley; there is no ambiguity in the statement. The words are clear and precise. The inventor says 'it is proposed to employ the electro-magnets in obtaining induced electricity which supplies wholly or partially the electricity necessary for polarising the electro-magnets, which electricity would otherwise have to be obtained from batteries or otherwise.'" In the absence of the full specification it seems almost certain that the inventor had not the faintest conception of the principle with which he is credited; on the contrary, his idea appears to be one of the ordinary perpetual motion mistakes. The patent is for an electro-motor, "a peculiar arrangement of apparatus for obtaining motive power by the aid of electricity," and the inventor, like many others, fancied he might persuade the machine to generate the electricity for itself, seeing that it was well known that such machines would generate electricity. With much more justice it is shown that Hjorth, in 1854 and 1855, combined permanent and electro-magnets in one system in such a manner as to effect what Wilde did in 1863, when he put two Siemens machines together, and made the one with the permanent magnet supply current to maintain the more powerful one with electro-magnets, from which the working current was to be obtained. But it is no uncommon thing for later knowledge or altered conditions to enable us to see approximations to recent invention in earlier ideas, probably very imperfectly realised by the early inventor. It is unjust to the later inventor, the man who sees and points out the real thing when it is wanted, to treat him as anticipated by others who led the way to a certain point, without seeing how to go further. This applies also in the case of Pacinotti, who is credited with antedating the interesting machines of Siemens, Wheatstone, and Varley, because he included the magnet coils and armature of his machine in one circuit. But this was a mere incident of no moment. The machine was a motor, and not a generator; it was to be worked by current from an external source, for which purpose it is an insignificant detail whether the two systems are connected in series or in multiple arc; it is a pure question of resistance and arrangement of battery, and, if anything, it was the worse plan for its purpose. The principle of accumulation was not hinted at, or, indeed, available, nor did Pacinotti himself see that by changing the arrangement and purpose of his machine it would become a generator.

This in no way diminishes Pacinotti's merits, for his statements, given very fully and clearly in this work, show that he clearly appreciated and intentionally developed the principles which underlie the rotating ring armature and the commutator, which are the basis of the Gramme and other subsequent machines; especially he clearly explained the advantage of doing away with extra currents and loss of energy in magnetising and demagnetising. That he did not at all perceive the principle of accumulation is evident from the fact that in converting his machine into a generator he used permanent magnets to obtain his originating force.

The Wallace-Farmer machine is estimated rather more highly than by most people, and its going out of use attributed to the circumstance that in this country it and the Brush were "controlled by the same interests." The fact is that the machine bears no comparison with others, owing to its size, weight, and lower work power.

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The various types of the De Meritens system are well described and illustrated, and a suggestion of improvement made on p. 203, which M. de Meritens will do well to carefully avoid. The Brush machine is also fully explained, but, after the custom of the writer, it is said to possess "some points of resemblance to the dynamo-electric generators of Gramme and Wallace Farmer, as well as to the magneto-electric generators of De Meritens." The fact is that it bears no resemblance whatever to any of these machines beyond the inevitable connection which exists among all the varieties of machine, which all depend upon the same natural principles. Therefore the further remark that "its principle of construction is different from that of all others, and confers upon it its special excellence and its originality," is but just.

The advantages of the Bürgin machine over the Gramme are fairly pointed out, and the machine with all its arrangements and details of construction clearly explained, so as to render its simplicity of construction and maintenance very evident, as also its working capacity, owing to the high surface velocity of the rotating armature, which its construction permits without risk of undue heating.

The Maxim and Weston machines are also fully and fairly described, and then various modifications patented by others are described, as also Edison's large machines, of which it is remarked that the armature belongs in principle to the Siemens direct current type, but the connecting up resembles the Gramme. The description of the Siemens machines of the earlier and recent types is interesting and full, and with descriptions of various later machines of more or less importance completes the chapter, which will enable the investigator to see what has been done thus far in the development of mechanical generators of current.

The chapter on Conductors gives a *resumé* of Ohm's laws and the relations of resistance, and explains clearly the different considerations involved where continuous or alternating currents are to be transmitted, and that a first-rate conductor for one may be very bad for the other, owing to the influence of capacity for charge and consequent retardation when alternating currents are used; but it is stated as the result of experiment and calculation that the effect of retardation is not of much consequence in circuits of less length than 58 kilometres. Experiments by Professor Joubert are given, showing that tarred thread gives a very inferior insulation, while the mixture of resin and paraffin gives excellent results, and the tests of Mr. W. H. Preece show the high insulation power of well-prepared ozokerit.

The different sizes of wire, or cable, employed for various purposes are given, as also a *resumé* of the modes of insulation and preparation adopted by different makers in France and England, and the information contained in this chapter will, no doubt, prove valuable to the many engineers who will have to deal with applications of electricity in the early coming time, but who have not studied the subject itself very thoroughly.

The succeeding chapter gives an account of the various processes of manufacturing carbons for the arc lamps, and a full detailed account of the preparation of the Jablockkoff candles, testing their quality, coating with copper, &c., and the amount of labour expended upon each stage of the process, which may be of interest to a limited number of readers.

The remainder of the book is occupied with full descriptions and drawings of the various forms of arc and incandescent lamps, and an appendix consisting of abstracts of patents relating to electric lighting and generators from 1837 to 1873, and a classified list of those from 1873 to 1882, and a similar list of American patents.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13. The publisher will be glad to purchase any of the above numbers.

I. THE TRANSMISSION OF POWER BY ELECTRICITY.*
II. THE PORTRUSH ELECTRICAL RAILWAY.

BY ALEXANDER SIEMENS AND EDWARD HOPKINSON, D.SC.

I. Nearly two years ago I addressed the society on the subject of "Electric Railways and the Transmission of Power by Electricity." I now venture again to bring the subject before you in conjunction with Mr. E. Hopkinson, in order to show the advance which has been made in the interval in actual applications, and to develop the theory of the subject more completely than was then possible. At the time of reading my former paper there existed only one electrical railway, viz., the Lichterfelde line, near Berlin, and even this had but a short time previously been opened for traffic. Since then Messrs. Siemens and Halske have constructed, in addition to their pioneer undertaking at Lichterfelde, a line, one and a-half mile long, from Charlottenburg to the Spandauer Bock, and a short line, worked only in the summer, in Kostverloren Park, near Amsterdam. They have also applied the system to a railway in the mines at Zankerode, in Saxony. At the International Electrical Exhibition in Paris, under the direction of Dr. Siemens, an electrical line was worked by Messrs. Siemens Frères, between the Palais de l'Industrie and the Place de la Concorde, which carried an average of over 13,000 passengers per week; and, more recently, in the north of Ireland, the towns of Portrush and Bushmills have been connected by an electrical railway, six miles long, which will presently be described in detail.

It is unnecessary to refer further to the Lichterfelde line, as the details of its construction were given in my previous paper; suffice it to say that for over two years it has worked continuously without hitch or accident of any kind.

The engine employed in the mines at Zankerode is shown in side view and in section on the diagram. The dynamo is placed with its axis lengthwise on the car, and works one pair of driving wheels by means of bevel gear. The current is conveyed along the roof of the workings by means of an inverted tee iron rail, on which a contact carriage freely slides, and connects with the engine by a flexible cable carried down the tube. The return current is taken by a similar cable and carriage to a second conductor, fixed by the side of the first. It is obvious that for mines the simpler method of using the rails themselves for conductors could not be advantageously employed, as they are in general very roughly laid, and frequently shifted, which would make it difficult to maintain proper electrical conductivity. The engine is reversible, and the handles making and breaking the current, and the brake levers, are worked from either end, so that the driver always faces in the direction in which the engine is moving. The gauge of the line is 18 in., the diameter of the wheels 13 in., the extreme dimensions of the engine—length between buffers 8 ft., width 2 ft. 7 in., and its weight 1½ ton. It can develop sufficient power to draw a load of 8 tons, at the rate of 7½ miles per hour. Without going further into details, these figures will be sufficient to show how powerful an engine it is for its bulk and weight, and its adaptability for the special purpose for which it was constructed.

Leaving for the present the subject of railways, I will now show two examples of electrical transmission of power, as illustrations of the diversity of its possible applications, and then describe the electrical lift, and use it to illustrate the general theory of the subject. First, there is here an ordinary centrifugal pump drawing water from the tank below, forcing it through the tube, and returning it again to the tank. The pump is worked by a strap from the Siemens machine, used as a motor, and the current is obtained from a somewhat larger machine, which is ordinarily used for lighting this room, but which, for the present, has been taken for the purpose of the experiment. Such a pump, coupled direct to its dynamo machine and mounted on wheels would make an excellent fire engine, as it is very easily handled, and can be started at a moment's notice by sending a current through it. At some future time, when electric mains run along our streets by the side of the water mains, there will be no difficulty in obtaining the necessary currents from "electricity" plugs placed alongside the fire hydrants. At present it would be necessary to transport secondary batteries with the electrical fire engine, but even with this drawback the great advantage would be obtained of having the full power of the pump immediately ready for use, and every minute gained is of importance. A further advantage lies in the possibility of connecting the water main direct to the pump as the pressure of the main would thus be utilised, and no water wasted. Now let the pump be disconnected, and replaced by the very small motor working the sewing machine. It is important to observe that the same generator is used in both cases, and that neither its speed nor any other of its conditions have been altered, excepting only the pull on the driving strap; but that, in the case of the pump, probably about

* Paper read before the Society of Arts on Wednesday, April 11, 1883.

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5 horse-power of useful work was being done, while in the case of the sewing machine perhaps one-fiftieth of a horse-power. Now, without stopping the sewing machine, the whole of the forty Edison incandescent lamps required for lighting this room shall be connected with the generator. The sewing machine still performs its one-fiftieth of a horse-power of work, while from the same generator and the same leading wires about 5 horse-power are employed in lighting the room.

These illustrations will be sufficient to show, in the first place, that when once we have electrical mains of sufficient capacity carried from central stations to our houses, how simple a matter it will be to combine lighting with domestic operations, and even the larger operations required for purposes of trade; and, in the second place, that each motor of a series placed in parallel circuit performs the work required of it independently of all the others, and independently of the generating machine, provided only that the generator is capable of producing the power it is called upon to furnish.

This second point I will now show to you in a different form, and explain it mathematically. The diagram represents an electrical hoist, designed by Dr. John Hopkinson, and made by Messrs. Siemens Brothers. The electrical part consists of an ordinary D_3 series dynamo, fitted with reversing gear for reversing the direction of the current and the lead of the brushes, and, consequently, the direction of rotation of the machine. In the mean position both pairs of brushes are lifted from the commutator, allowing no current to pass. The dynamo runs at a high velocity, and, consequently, is connected by spur gear to the lifting axle, to diminish the speed of lift and increase the leverage. On this axle a chain pulley is fitted by means of a special friction clutch, which need not now be explained. The clutch automatically holds the weight attached to the chain as soon as the dynamo is stopped. Having coupled up the leads to the terminals of the machine, and hung a weight of one hundredweight on the chain, start the dynamo, measure roughly the speed of lift, and by means of the electro-dynamometer the current passing through the dynamo—

Weight.	Speed.	Current.
1 cwt.	4ft. per sec.	9 amperes.

Now, let the attached weight be doubled without altering any other conditions, and again measure the speed and current—

Weight.	Speed.	Current.
2 cwt.	2·5ft. per sec.	13 amperes.

You will obsereve, as you would expect, that with the heavier weight, the speed has diminished and the current increased.

Secondly, I will again put on the weight I had in the first experiment, but insert a resistance of — ohms in the leading wire. Again, measuring the current and the speed, we have—

Weight.	Speed.	Current.
1 cwt.	2ft. per sec.	9 amperes.

You will see that the current is exactly the same as before, while the speed has diminished. Taking again the double weight, and leaving the resistance inserted, we have—

Weight.	Speed.	Current.
2 cwt.	1ft. per sec.	13 amperes.

Again the same current as we had before with the double weight, but a diminished speed. From these experiments, it is clear that for a given load the current remains constant, whatever the speed may be, and that the speed principally depends upon the resistance through which the current passes.

On the diagram is shown the results of a series of experiments with the same hoist, made at the works of Messrs. Siemens Bros., under conditions which allowed of greater accuracy than is possible here to-night.

Resistance inserted in circuit, in ohms.	Work done. Load 56lb. 7·3 amperes.		Work done. Load 1 cwt. 9·2 amperes.		Work done. Load 2 cwt. 12·9 amperes.	
	Speed in feet per minute.	Foot lbs. per minute.	Speed in feet per minute.	Foot lbs. per minute.	Speed in feet per minute.	Foot lbs. per minute.
·3	212	11,870	180	20,160	130	29.120
1·2	190	10,640	164	18.370	112·5	25.200
2·2	169	9,480	150	16,800	90	20.160
3·2	157	8,790	130	14,560	71	15,960
3·7	150	8.400	125	14.000	59·5	13,330
4·8	141	7,850	111	12,430	36·5	8,180
5·7	130	7,280	90	10,080	19	4,260
6·3	129	7,200	84	9,410	—	—
8·3	98	5,480	56	6.270	—	—
9·7	80	4,230	27·3	3.060	—	—
11·6	47	2,628	—	—	—	—
12·7	35	1,960	—	—	—	—
14	18	1,008	—	—	—	—

Three conclusions are to be drawn, which are the fundamental principles of the theory of the electrical transmission of power.

I. The motor, as a machine, is entirely independent of the generator, and must be designed for the particular work it has to do without reference to the generator.

II. The current depends upon the load on the motor, and upon no other thing whatever.

III. The speed depends upon the E.M.F. of the generator, and the total resistance in the circuit of the machines. If the mains which supply the current to the motor be maintained at a constant potential, and the motor be separately excited, or have permanent magnets, the speed is proportional to the potential of the main, less the loss of potential due to the resistance of the armature.

As a practical corollary, the generator must be designed to give the current required of it by the motor, and E.M.F. sufficient after allowing for fall of potential through the resistance of the mains, to give the requisite speed. Keeping these points in view, it is easy to design a combination of machines for performing any particular work, and to calculate exactly the efficiency of the combination, and to account for the various losses that occur.

(TO BE CONTINUED.)

ON SECONDARY BATTERIES.*

BY GEORGE F. BARKER, OF PHILADELPHIA, PA.

(CONCLUDED FROM PAGE 502.)

[ABSTRACT.]

But a second form of it has been used in which the coil is made of finer wire and is placed in a shunt circuit as shown in Fig. 3. In both cases, of course, the entire current passes through the contact springs.†

After charging, the current from the secondary battery was used to maintain seventeen Edison incandescent lamps of the B pattern. More frequently, however, the battery was used in connection with the Gramme machine. The source of power being an Otto gas engine which, at best, has an explosion only every fourth stroke, the motion appears very irregular when tested by so delicate a method. As every explosion increases the speed, the higher electromotive force developed increases for an instant the brightness of the carbon filament, producing a marked pulsation in the light. If now a secondary battery of nearly the same electromotive force be placed in multiple circuit with the machine and lamps, it acts as an equaliser, and destroys entirely the pulsations. Figs. 2 and 3 show the arrangement

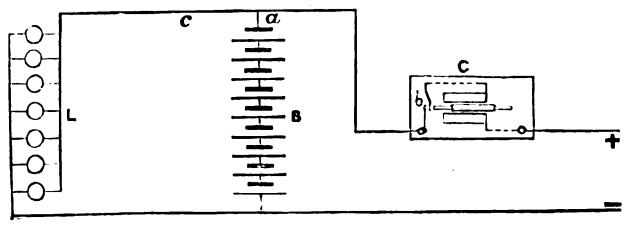

FIG. 2.

actually employed, in which B is the secondary battery, and L the lamps; the automatic cut-out being at C. When the circuit is opened at *a*, *b* and *c* being closed, the lamps are fed by the machine alone; when opened at *b*, *a* and *c* being closed, by the battery alone; when at *c*, *a* and *b* being closed, the machine

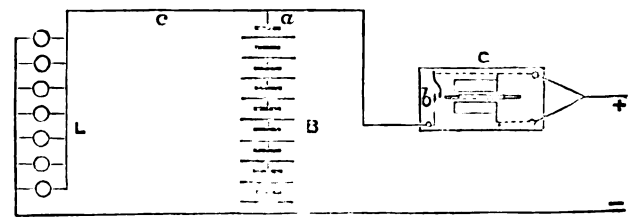

FIG. 3.

charges the battery. When all three are closed, the lamps are fed by the machine and battery together, the latter acting as an equaliser. A galvanometer inserted at *a*, *c* being opened and *b* closed, indicates the charging current; when *c* is closed and *b* open, the discharge current; and when *b* and *c* are both closed,

* From the *Proceedings* of the American Association for the Advancement of Science, Vol. XXXI., Montreal Meeting, August, 1882.

† Sir Wm. Thomson has devised a polarised cut-out for this same purpose. He exhibited it at the York meeting of the British Association in September last.

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the equalising current. If the electromotive force of the machine-current be but slightly in excess of the battery current, the deflection to the right in the first case will about equal that to the left in the second; so that in the third case the deflection is practically zero, not the least spark appearing on opening at *a*; and this, though the pulsations are completely destroyed, the light being perfectly steady. The advantage of a much more agreeable light is thus secured; but in addition the life of the lamps must be increased by the use of this steadier current, as it has been shown to be by using the secondary battery alone.

On the 27th of February the battery was charged continuously for fourteen hours, or until hydrogen was freely evolved from each of the thirty-two cells employed. It then gave an electromotive force of 59·3 Daniell cells; or calling the Daniell 1·08 volt, of 64·04 volts. On the 10th of June, the same thirty-two cells gave an electromotive force of 56·7 Daniell's, or 61·2 volts. On the 24th of June, their electromotive force was 54·3 Daniell's, or 58·6 volts. It may be assumed, then, that the average electromotive force of a single cell was not far from two volts. This value has never been exceeded in any of the measurements made, either on single cells or on groups of cells. When first made, the resistance of the single cells was low, about 0·02 ohm; but subsequently the internal resistance increased considerably, rising even to twice this value.

The chief defect of the secondary lead battery is the local action which takes place in it. By local action is meant any deterioration in the efficiency of a battery which occurs when it is left on open circuit. This defect was noticed by Planté, who says:—"If the lead peroxide deposited on the positive plate had no tendency to spontaneous reduction in the acidulated water, by forming a local circuit with the metal that it covers, the preservation of the charge taken by the secondary couple should be indefinite. But this peroxide is reduced, and with the more facility as the layer of it is thinner. In a new secondary couple the charge cannot be preserved." In a well formed battery he attributes the preservation of the charge to a reduction of the superficial layer to monoxide, which acts as a protecting coating. Another local action, however, takes place in this battery, which appears to be of more importance. This is the action of the sulphuric acid upon the products of electrolysis. The finely divided lead on the negative plate, as well as the peroxide upon the positive, is alike converted into sulphate by this action. When the circuit is closed this action is normal; but it takes place equally well when the circuit is open. It is then abnormal, and, of course, injurious. The formation of lead sulphate in the secondary battery has been studied by Gladstone and Tribe.* They found that with a Planté cell the whole of the peroxide formed on charging was converted into white sulphate within seventeen hours. The same fact was observed with the Faure battery. So far, however, from regarding this formation of sulphate as wholly injurious, they regard it as "absolutely requisite in order that the charge should be retained for a sufficient time to be practically available." They believe that the insoluble lead sulphate clogs up the interstices of the peroxide and after a while forms an almost impermeable (*sic*) coating between it and the lead plate; so that the mass of peroxide which is in contact with the lead plate expends its energy slowly, while the same mass of peroxide, brought into connection through its own lead plate with another lead plate at a distance, expends its energy even through the sulphuric acid, in a tenth or a hundredth part of the time.

My experiments with the Faure battery above described confirm entirely those of Gladstone and Tribe as to the formation of lead sulphate. In several cases, the acid in charged cells disappeared entirely on standing so that the water was tasteless; and in some instances this was repeated three times with the same set of plates. This action increased very greatly the internal resistance, first by replacing the acid by water and second by forming the higher resistant sulphate. On examining the plates, lead sulphate formed the entire coating upon both of them. On attempting now to recharge such a cell, this notable increase in the resistance showed itself in the reduced current transmitted by the same electromotive force. Gradually, however, the resistance fell and the current finally regained its normal strength. In one instance the charging current rose from two amperes to 12, in four hours, 28 cells being in circuit, arranged in series. It was observed, however, that when the current was first applied torrents of gas were evolved from both plates; and that as the charging process went on the oxygen was first completely absorbed and then the hydrogen. When the charge was nearly complete the evolution of hydrogen reappeared. There would seem, therefore, to be a very considerable loss of energy, due to the resistance consequent upon the formation of sulphate. In the first place the current energy is wasted as heat in the cells; and in the second, a large portion of it is dissipated in the evolved gases.

Another defect of considerable magnitude is developed when a number of secondary cells is placed in series, and is due to a want of uniformity in their capacity for storage. This arises, probably, first, from the difficulty of constructing them exactly alike originally, and, second, from the impossibility of uniform action among them on charge and discharge. The difference in the cells of the same battery even, when they all have been treated precisely alike, is surprising. On the 14th of June, 32 cells were freshly charged, and the current strength from each cell measured on a tangent galvanometer. Eleven cells gave 80deg. deflection each, 17 gave 79deg. each, one gave 78deg., one 77deg., one 75deg. and one 20deg. When 17 Edison B lamps were placed in circuit, the discharge deflection of the 32 cells in series was 67deg. On the following day the battery was charged again, and, after an hour's use on the lamp circuit, was again tested. Those giving a deflection of 87deg. were two; of 86deg., two; of 84deg., two; of 83deg., one; of 81deg., one; of 78deg., five; of 77deg., two; of 76deg., one; of 13deg., three; of 11deg., one; of 10deg., three; of 8deg., one; of 6deg., one; of 5deg., three; of 4deg., one; of 2deg., one; of 1deg., one; and of 0deg., one. Obviously, so long as any peroxide is present, the electromotive force is constant; hence this wide variation of current strength must be attributed, apparently, to the variation of the resistance in the different cells. But this is not the worst aspect of the matter. If the discharge be continued for a longer time, some of the cells become exhausted sooner than others, and are then charged in the inverse direction by the current from the rest. On the 12th of June, the thirty-two cells, after pretty complete discharge, were measured as above. Nineteen cells gave positive deflections ranging from 87 deg. to 5 deg.; thirteen gave negative deflections varying from 13 deg. to 1 deg. Faraday said of primary batteries in 1834, that "weak and exhausted charges should never be used at the same time with strong and fresh ones in the different cells;" and this remark is even more applicable to secondary batteries, where this condition is more liable to occur. Not only does a dead cell introduce resistance into the circuit, but what is of more importance, its reverse polarisation introduces a counter electromotive force, so that every such cell neutralises another cell, the dead resistance of which is also added to the circuit. In consequence, it is not safe in practice to draw from a secondary battery all the energy it should be capable of yielding, and in most cases not more than half can be safely taken out of it. In place of continuing uniform as in a single cell, the electromotive force of a series of cells begins to fall when about half the charge which it ought to be capable of yielding has been drawn from it. The practical result is that to supply for lighting a definite number of coulombs of electricity, a secondary battery of twice the size is necessary under these circumstances.

With reference to the two forms of lead secondary battery devised by Planté and by Faure respectively, my experiments show that while the electromotive force is the same in both, and while the internal resistance and storage capacity may readily be made the same, yet that the local action is far less when the peroxide is formed by the action of the current upon the lead plate itself than when it is produced from minium spread upon it. The rapidity of the formation of the peroxide is proportional to the density of the current; but when rapidly formed it is fine and spongy. In one of my Planté cells, the peroxide is beautifully crystalline and very hard. Not a trace of sulphate has been formed in it apparently, though it has been in use for six months, and has been frequently charged and discharged during that time. The necessarily finer condition of the peroxide in the Faure battery would seem to predispose it to a more considerable local action. True, the Faure battery requires very much less time than the Planté to form it. But this is more than compensated by the increased permanence of the latter. With an equal storage capacity, as in M. de Kabath's form of Planté cell, it would appear that in efficiency it will surpass the form devised by Faure.

The commercial aspect of the question of the storage of electrical energy has recently assumed a very considerable importance. But it is evident at the outset that an agent, which has been produced and then stored, must cost more when redelivered than when first produced, by exactly the cost of the storage; that is, supposing there is no loss in storing. But there is a loss, and this is almost, if not quite, one-half of the energy involved; as it would seem from the Conservatoire experiments in Paris, among others. The first cost of the accumulators, the expense of charging them, their low efficiency, and especially their bulk and weight, must ever prevent, it would seem, their competing successfully with the direct use of the dynamo-electric machine, at least with any form of secondary battery yet devised. For special uses, however, the storage battery has a high value. Even

* *Nature*, XXV., 221, 461; XXVI., 251, 1882.

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if the cost of an ampere of current produced by it is twice as great as if produced directly by the dynamo machine, this cost is only one-half of that required to give the same current by any available form of primary battery. Where a strong current of low electromotive force is needed, under conditions where a dynamo cannot be employed, there the secondary battery has its most important field. Its value rapidly decreases as the number of cells is multiplied, as when a high electromotive force is needed for the production of light. Its chief advantage is its transportability; since by placing it near the work to be done the loss of energy on long conductors is obviated.

MAGNETISM.

BY JOHN T. SPRAGUE.

1. The magnetic property of a natural substance, ferrosoferric oxide F_3O_4 or $FeO + Fe_2O_3$, known as the loadstone, was discovered in early times from its power of attracting and adhering to iron. It was afterwards discovered that the loadstone imparted its powers to steel, and that masses of steel thus acquired a variety of peculiar properties besides that of merely attracting iron.

The first striking property is a directive power by which a bar of magnetised steel always places itself in one position, with one end pointing towards the north; the next is that when two such bars approach each other two of the ends attract and two repel each other, instead of displaying a constant attraction, as with iron.

2. In examining these properties we find that the force, be it what it may, which is acting, is concentrated mainly at the two ends of the bar, towards which the holding power on iron is greatest; thus, if a bar magnet be rolled in a mass of iron filings, these will adhere to it in the manner shown in Fig. 1;

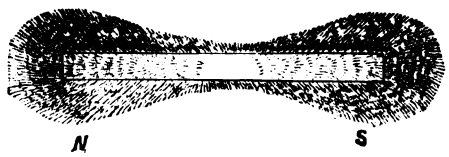

FIG. 1.

so if it is measured by the actions on a suspended needle, the force is represented mathematically by a curve shown in Fig. 2, which exhibits half a bar magnet, and shows that the point of greatest force, or what is called the pole, is not at the actual extremity, but a distance within, varying with the length and form of the magnet. These figures are identical with those

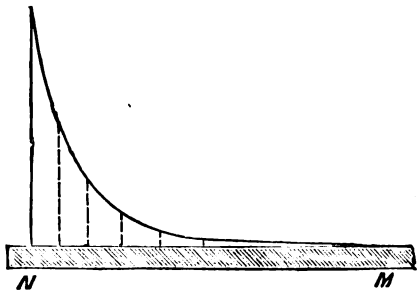

FIG. 2.

which represent the distribution of electricity, and hence there was early perceived a relation between magnetism and electricity, and this naturally, in times when men never hesitated to create any power which would serve to explain a fact, led to the hypothesis of two magnetic fluids, the Austral and Boreal, now entirely abandoned, although their brethren, the electric fluids, are still cherished by many philosophers.

3. A remarkable feature in magnetic force is that it apparently acts at a distance without relation to intervening substances, providing these are not themselves magnetic. Different substances, such as iron, nickel, and, to some slight extent, all bodies, have *magnetic capacity* in varying degree, but this is unlike electrical capacity. In electricity all materials have equal capacity as to the surface charge, but different capacities as to forming the field of force. In magnetism the different capacity is in receiving and retaining the charge of force, while the surrounding field forms equally in all bodies not themselves magnetic. Hence a magnet acts just as powerfully through a sheet of glass as through air. If, therefore, we place a sheet of glass over a bar magnet, and sift iron filings over it, these arrange themselves in obedience to the force, if we lightly tap the glass to aid them in moving. Fig. 3 shows the result, the filings arranging themselves in closed curves which exhibit the lines of force surrounding the magnet, and on which, or, rather, on the tangent to which, at any part, a suspended magnetic needle will place itself. This figure represents, therefore, a section of a magnetic field; the field itself of course extending round the magnet in all directions. It also enables us to perceive that magnets do not act simply at a distance; they induce in all surrounding matter a condition which is the source of magnetic action; but it is only some forms of matter, of which iron is the most important, which render this condition active as magnetic force, and are themselves capable of retaining that condition, and transmitting it afresh.

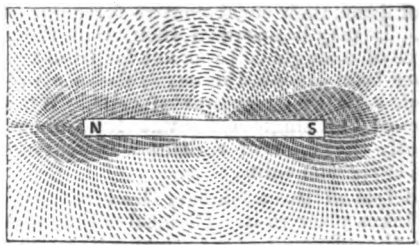

FIG. 3.

The forms or curves which may be obtained in this manner vary infinitely according to the position of the several poles in a field; they are in fact formed upon precisely the same principles as are explained in my article on the induction and conduction circuits, p. 247, and render visible in magnetism the lines and fields of force which can only be perceived by the imagination in electricity.

4. To understand the magnetic condition, we must examine the magnet itself. Thus far we see in it a resemblance to electrified cylinders with the + and − charges apparently collected upon their separate ends. If, however, one of those cylinders is divided across the middle, we obtain the two parts in the opposite states, one wholly +, the other wholly −, and there is thus some ground for the idea that we have really separated two fluids. But this is not the case if we break a magnet across, for we find that two perfect magnets are produced, two fresh and opposite poles being generated out of the previously inert middle, while the forces these possess are taken from the original terminal poles, the attractive powers of which

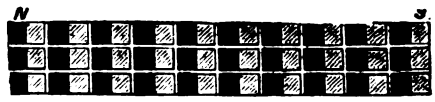

FIG. 4.

are reduced. We may repeat this process to an unlimited extent till we convince ourselves that the perfect magnetic power resides in every minute particle; in fact, that magnetism is a force belonging to and residing in the molecules of which the magnet is composed. This view of the nature of a magnet is well expressed by Fig. 4. This presents the magnet as consisting of a collection of polarised molecules symmetrically arranged, the force of each series exhibited at its two ends, and completing the circuit of polarisation or force through surrounding matter in the curves shown in Fig. 3. This conception is strictly correct as to the facts of magnetism itself; but when we come to the theory and to the evident connection of magnetism and electricity, it is apt to generate confusion of ideas, owing to the apparent resemblance between the polarised molecules in both cases.

5. To avoid this confusion, and more intelligently to examine the facts and the true relation of the two forces to each other, and to the molecules of matter, it is desirable to define those relations in accordance with the relations of electricity to mater. Electricity and magnetism then are the same force, and are two actions of polarised molecules, manifested at right angles to each other, and both developed together. Electricity is the action which occurs *in the line of polarisation*. Magnetism is the action which occurs *at right angles to the line of polarisation*, and in all directions at right angles to that line. But there are some important distinctions to be noticed. Electricity is essentially a dynamic force; its nature consists in producing motion in, and transmitting energy along, the polarised chains; its static actions are only incidents of this process dependent on the resistance offered to the completed motion. Magnetism is, on

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the other hand, purely static; it consists in the storing up of energy in the polarised molecules. It should also be remarked that while magnetism is an essential consequence of and attendant upon electric polarisation, it is only manifested as magnetic action by certain substances which possess the faculty of assuming that condition which constitutes a magnet; of these iron, nickel, and cobalt are the most effective, and this state is only produced and manifested by dynamic electricity, and in degree proportioned to its quantity. Considered from this point of view, Fig. 5 represents a typical molecule, and this figure thoroughly mastered and fixed in the memory will answer every possible question as to the relations of magnets and currents, the action of helices, galvanometers, coils, &c. A magnet

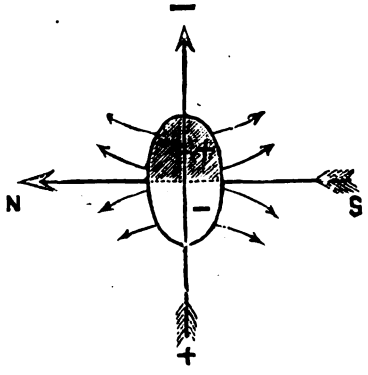

Fig. 5.

will always place itself at right angles to such a molecule (forming, of course, part of a polarised chain), with its north end to the left hand, looking from the molecule itself, so that the arrow or magnet N S is supposed to be on the farther side of the molecule. There is, however, no true directive force in this action, no north and south *sides* to the molecule itself, as there are + and — *ends*, but the directive tendency is the same at right angles to *any radius* of the molecule at right angles to its line of polarisation. Thus, if the molecule or current be vertical, and a suspended needle be carried round it, the needle will retain the same relative direction to the molecule, but will make an entire revolution on its own axis, and its extremities will point in turn to every direction, provided the directive action of the earth is neutralised, as by a fixed reversed magnet.

Fig. 6 will illustrate this. A shows a section of a conductor carrying current, or of the molecule in Fig. 5, with its radial lines at right angles to which external magnets will place themselves. B represents a filament of a magnet such as is shown in Fig. 4, which conveys a correct idea of the *magnetic* polarities

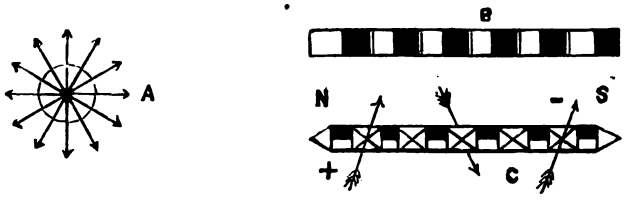

Fig. 6.

in successive sections, while C exhibits the circular polarisation in these sections, which is the probable electrical cause of the magnetic force. The arrows show the directions of a current which would set up this polarisation, and generate the N S magnetism shown.

By aid of these figures the student may realise the idea usually employed since Ampère devised it in order to fix on the memory the relations of magnets and currents; for, let the reader conceive himself *to be the molecule*, Fig. 5, the current of which he forms part, entering at his feet, his head, therefore, being the + extremity; his right hand will have the magnetic actions of a N pole to any object at which he is looking, and therefore any magnet in front of him will present its N end to his left-hand, the magnet itself standing fairly across him in front in whatever direction he may turn.

7. *Ampère's Theory.*—As before remarked, magnetism was formerly explained by the invention of two fluids; but the theory now generally received is that of Ampère. Working from the fact that a circular electrical current constitutes a magnet at right angles to its plane, and that electro-magnets are practically composed of a series of such circular currents ranged in the form of helices, and also from the fact that the force is evidently possessed completely by the molecules of permanent magnets, he taught that magnetic substances are composed of molecules around which electric currents are always flowing; that in the unmagnetised condition these molecules and currents are arranged haphazard in all directions, and that the act of magnetising consists in arranging them in parallel order. Fig. 7 exhibits this theory; it shows the magnet built up of the molecules with their currents acting as does an external current shown by the arrows. The bar S shows a longitudinal view of the same magnetic system. The theory explains all the facts of magnetism, but beautifully scientific as it is, there are fatal objections to it, not generally seen. In the first place, it is based

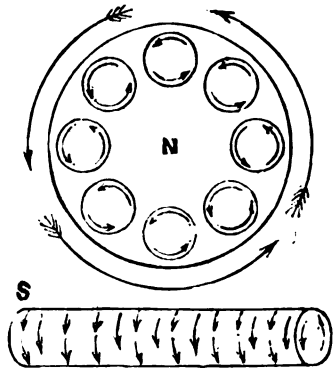

Fig. 7.

on the idea of electricity being an entity, a something which can circulate round the molecules in a real stream, and therefore it is inconsistent with more recent views as to the nature of electricity; but apart from this, though we might assume it to be possible that such circulating currents might be confined to the molecules, it is impossible to conceive how they fail to arrange themselves symmetrically always, or why, once arranged, as in magnetised iron, they derange themselves at once the moment the inducing magnet is withdrawn. The very nature of electric currents would require a *coercive force* to prevent the magnetic condition being always existent, whereas the reverse is the fact.

8. *The Molecular Theory.*—This theory of electricity is equally adapted to magnetism, takes possession of all Ampère's work, and adopts all the facts and all these are unaffected by the substitution for the assumed circulating molecular currents, of the conception of the polarised molecule exerting influence upon all the neighbouring molecules and arranging them in systematic polar order. Fig. 8 shows at a glance both the remblances and differences of the two theories. N shows the molecules retained as a polarised chain, analogous to the conditions of static electri-

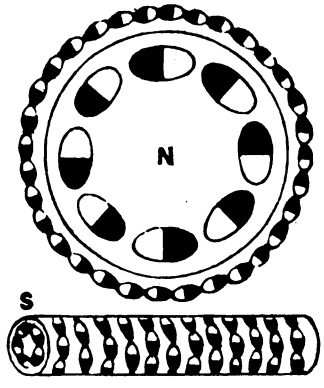

Fig. 8.

city, and it shows how an electric current generates this state in a bar around which it circulates. The coercive force of the magnet is due to the resistance of the molecules to the change of condition, either to being magnetised or demagnetised in the case of steel, the molecules of which are compound, while iron has little power to resist either. What gives the molecules of iron and steel these properties we do not know. But certain properties are apparently connected with the atomic weights of the elements, which have been classed into groups dependent on numerical relations of these weights. A Russian savant, M. Mendelejeff, has found some difference of properties according to whether the atomic numbers belong to an even or an odd series, as to which information may be found in the second supplement to Watts's

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"Dictionary of Chemistry." It appears that magnetic bodies all belong to the even series, and that diamagnetic bodies belong to the odd series, and that as to these latter the diamagnetism increases with the atomic weight.

9. Those who desire to study magnetism thoroughly will find some useful suggestions as to experimental means in papers by Dr. Shettle to be found in Vol. III., pp. 10 and 44 of *The Electrician*. His object was to show that magnetism is a spiral force rather than a longitudinal one, but his theory involves, like Ampère's, a continually maintained current of energy, and it is difficult to conceive how such a current can be maintained. The spiral order of the molecular arrangement both as to magnetism and electricity may be almost considered to be established by the experiments of Professor D. E. Hughes, who gave to the world the microphone and the induction balance; he has proved that the passage of a current through an iron wire produces in it a permanent molecular strain, which is evidently of the nature of a twist or spire, the direction of which depends on that of the current; this twist can actually be removed by a mechanical twist in the opposite direction, or by the application of a magnet pole. He also proved that this molecular twist, in the act of being untwisted mechanically, generates an electric current, just as does the ordinary cessation of magnetism. Professor Hughes has recently extended these observations in examining the nature of steel as an alloy of carbon and iron, and into the effect of "temper." His results promise important practical teachings and useful modes of testing the quality of steel as suited to different uses, and his papers should be studied by those interested in these subjects. The apparatus for the investigation is very simple; it consists of a tube with a coil of wire upon it, through which the wire to be examined passes and becomes the core of an electro-magnet; a battery and an interrupter is connected either to the coil or the wire, and a telephone to the other; each mode of connection has its use according as it is desired to observe the molecular effects produced on the core by a current, or the reactions of the wire in generating currents in the coil (when the battery would not be used) under the influence of torsion.

10. A magnet is usually thought of as merely a piece of steel in which a certain force resides; it is evident that this is only a part of the magnet; the external field of force which accompanies it is as essentially a part of it as the steel itself, and the actions of magnetism are all of them merely transfers of the energy of this field and rearrangement of its lines of force. The directive energy of the magnet is due to the inductive action of the energised molecules, tending to range all neighbouring molecules in the same order as themselves. They thus set up a magnetic field (which is a resolution of the forces exerted by the various acting molecules) in which all the particles of air and common matter range themselves, like the filings in Fig. 3; when a magnetic body enters this field its molecules range themselves in obedience to it, and by their own power set up a field of their own; when the body entering the field is already magnetised permanently, and therefore has its molecules already so ranged, or is temporarily magnetised circularly by being the conductor of an electric current, then, if movable as a mass, it is turned or attracted, or apparently repelled, in such manner as to most energetically form part of the original lines of force or magnetic field; but if it cannot move it reacts upon the field and moves the magnet if movable, and a new field is set up which is the resolution of the forces of the two or more magnets within it.

(TO BE CONTINUED.)

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SLIP

HONOURS FOR AN ELECTRICIAN.—Her Majesty has been pleased to confer the honour of knighthood upon Dr. C. W. Siemens, F.R.S.

INDO EUROPEAN TELEGRAPH COMPANY.—The next ordinary general meeting of this company will be held at the Cannon-street Hotel, on the 30th inst., at twelve noon.

CHANGE OF ADDRESS.—The River Plate Telephone and Electric Light Company have removed their offices to 34, Walbrook, E.C., and Mr. R. H. Krause has been appointed secretary.

ELECTRIC LIGHTING IN THE CITY.—The Commissioners of Sewers have agreed to continue their contract with the Maxim-Weston Company for a further period of three months, at £400.

A VOLUNTEER TELEGRAPH CORPS FOR INDIA.—It has been suggested that a special telegraph corps should be formed of the volunteers in India who belong to the Telegraph Department.

MONTEVIDEAN AND BRAZILIAN TELEGRAPH COMPANY.—This company give notice that they will pay the dividend of 2s. per share, declared at their meeting on the 5th inst., on and after the 30th inst.

OPPOSITION TO THE ELECTRIC LIGHT.—The Westminster District Board of Works is organising a meeting of delegates from those local authorities who are opposed to the introduction of the electric light.

THE CHARING CROSS ELECTRIC RAILWAY.—The consideration of the Charing-cross Waterloo Electric Railway Bill by a select committee of the House of Commons has been postponed to Tuesday, May 1.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the half-month ended the 15th April are £4,026, as compared with £3,754 in the corresponding period of 1882.

ELECTRIC LIGHT LEADS.—With our next week's issue we shall publish No. 3 of our Supplements, which will be in the form of a table giving the loss of potential in volts, in 100 yards of outgoing and returning lead.

THE WEST COAST OF AMERICA TELEGRAPH COMPANY.—This company give notice that the tariff from Great Britain to Buenos-Ayres, and all stations in the Argentine Republic, viâ Galveston, has been reduced to 13s. per word.

FRANCE AND THE VIENNA EXHIBITION.—A decree has been published authorising an extraordinary grant of 80,000 francs to the French Ministry of Posts and Telegraphs for expenses in connection with the Vienna Electrical Exhibition.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending 13th April, 1883, were £2,474, after deducting the "fifth" of the gross receipts payable to the London Platino-Brazilian Telegraph Company.

COPPER WIRE.—We have received a copy of a useful table just published by Messrs. Walter T. Glover and Co., of Manchester, giving the relations between the dimensions, lengths, resistances, and weights of pure copper wire, from 0000 B.W.G. up to 30.

AN ACQUISITION.—We learn that Mr. Frost, Librarian to the Society of Telegraph Engineers and of Electricians, has secured for the library of that society the large collection of pamphlets relating to Electricity and the Electric Telegraph collected by the late C. V. Walker, F.R.S.

THE ARREST OF M. PHILIPPART.—A *Times* telegram, dated Brussels, April 12, stated that M. Philippart, the Belgian financier who was arrested in Paris, would probably be given up to the Belgian authorities, as his books were discovered to have been tampered with.

PHŒNIX ELECTRIC LIGHT COMPANY.—The liquidator of this company, Mr. Henry Bishop, has given notice that all creditors of the company must send particulars of their claims to him at 41, Coleman-street, E.C., before the 10th May. The date for adjudicating upon the claims has been fixed for the 23rd May, at 12 noon.

ELECTRIC LIGHT IN EDINBURGH.—On Tuesday night, between eight and nine o'clock, the Brush Electric Light Company of Scotland had one of their arc lights, with a large reflector, in operation at an opening in the wall of their premises in Market-street. The apparatus was on a swivel, and was turned rapidly here and there to show its power of illuminating distant objects.

THE FRENCH MINISTER OF TELEGRAPHS.—M. Cochery, French Minister of Posts and Telegraphs, accompanied by M. Hérisson, the Minister of Commerce, and M. Felix Faure, Deputy for Havre, arrived in Liverpool on Monday afternoon on a visit of inquiry in reference to the English mail system. A further object of their visit is to obtain information as to the working of the English Postal and Telegraph Services.

THE EDISON SYSTEM IN NEW YORK.—The Western Union Telegraph Building, at the corner of Broadway and Dey-street, New York, is about to be lighted from the Edison Central Station. An American contemporary says that it is being wired for 345 lamps, though at present but 255 are to be used. These are distributed as follows:—Associated press room, 55; operating room, 107; ground floor, 55; halls, 8; first and second floor, of No. 8, Dey-street, 15 each.

THE TELEPHONE IN BUENOS AYRES.—The *Buenos Ayres Herald* of 20th March last informs its readers that the Pantelephone Company of that city has agreed to unite with the Bell Telephone Company, under the joint title of "La Union Telefonica del Rio de la Plata." The chairman of the company is Major Alexander Wood, of the Western Brazilian Telegraph Company, and its managing director Mr. F. W. Jones, late general superintendent of the Telephone Company of Brazil.

SOCIETY OF TELEGRAPH ENGINEERS.—At the meeting of the society to be held at 25, Great George-street, S.W., on Thursday, April 26, at 8 p.m., the discussion will be continued on the following papers:—"On Some New Forms of Telephone Transmitters, with a Note on the Action of the Microphone," by John Munro, Associate; "On the Influence of Surface Condensed Gas upon the Action of the Microphone," by I. Probert and Alfred W. Soward, Associates; "On Microphonic Contacts," by Shelford Bidwell, M.A., LL.B., Associate.

ELECTRIC AND OTHER CLOCKS IN GLASGOW.—At a recent meeting of the Glasgow Town Council it was stated that the Bazaar Committee "had twice visited the 18 electric clocks in the city, and on each occasion had found them all correct. The 19 turret clocks under the charge of the committee had also been visited, and 10 were found correct, 8 being slightly wrong and 1 standing." It is hardly necessary to add that the council were so favourably impressed by this report that it was proposed to take steps to have the 19 turret clocks regulated by electricity. In the end, however, the matter was referred back to the committee for consideration.

A NON-INFLAMMABLE INSULATING MATERIAL.—Mr. W. A. Phillips, of Homerton, and Mr. S. E. Phillips, of Charlton,

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have taken out a patent for an improved method of making the insulating bodies of electric light conducting wires non-inflammable. The invention consists in passing the wires, covered or uncovered, through a solution of tungstate of soda. According to another part of the invention a concentrated aqueous solution of tungstate of soda is prepared and poured into boiled linseed oil, which is heated and kept stirred until the water has evaporated. A portion of this fluid is then mixed with the insulating compound used to cover the wire. The number of the patent is 2571, and it is dated 31st May, 1882.

Sixpenny Telegrams.—In *The Times* of the 18th April there were three letters on this subject, one from Mr. Horace Lennard, stating that the plan suggested by Mr. Latimer Clark in a previous issue of having fast and slow telegrams was already in vogue in the United States, and had proved itself to be practicable. The second letter was from Mr. H. Weaver, managing director of the Anglo-American Telegraph Company, who proposed the adoption for inland telegrams of the "word" system of charging messages. One halfpenny to be charged for each word, free addresses to be done away with, and senders to be allowed to forward any number of words they like. The third letter was an appeal from Colonel F. T. Maitland for the extension of the telegraph to country districts.

The Porterage of Telegrams.—In the House of Commons on Thursday week, Mr. Dalrymple asked whether it would be possible to reduce the present charge of 1s. per mile for the delivery of telegrams in the country, to which Mr. Fawcett replied that the charge of 1s. per mile was for the delivery of telegrams by mounted messengers at distances of three or more miles. The whole charge was paid over to the messenger, and the Post Office made no profit out of it. In Ireland, where mounted messengers could generally be procured at 8d. a mile, that was all that was charged. It was only the actual cost of delivery that the public were required to pay in any case, and if a message could be sent by a foot messenger instead of a mounted messenger at a cheaper rate, no objection was made to this being done.

Electric Lighting at Kimberley, South Africa.—We have received the following description of the installation, on the Brush system, which has been working for some time past at Kimberley, in South Africa, from a correspondent. He writes:—"The installation consists of 32 Brush arc lamps, supplied by two 16-light machines driven from a countershaft by a Robey engine of 20 nominal horse-power, which makes 130 revolutions per minute, the machines going at 800 per minute. One circuit, three and a half miles in length, extends round the Kimberley mine, the other circuit, four miles in length, to De Beer's mine, down Du Toit's Pan and Victoria Roads. The wires are carried partly on the roofs of the houses, partly on iron poles. The light is at present giving great satisfaction. The work has been carried out under the superintendence of Mr. R. L. Cousens, A.S.T.E. and E., electrician to the South African Brush Electric Light and Power Company."

Electrical Exhibition at Philadelphia.—A circular issued by the Treasury Department of the United States in regard to the electrical exhibition to be held by the Franklin Institute, at Philadelphia, states that "articles arriving at the ports of Boston, New York, or Baltimore, destined for the exhibition of 1883 or 1884, may be shipped by bonded common carriers from the port of first arrival to Philadelphia. On arrival at Philadelphia they will be taken possession of by the collector of customs, and an entry for warehouse in the usual manner will be required, after the bonding of the exhibition building, whereupon an appraisement will be made, and the rate and amount of the duties determined. Storage of the merchandise will be permitted in a portion of the building, duly bonded. Goods withdrawn for consumption on payment of duties, after one year from the date of their importation, will be subject to an additional duty of 10 per centum of the duties otherwise accruing."

Electric Fire Alarms.—We understand that Messrs. Griffith and Co., Telegraph Engineers, of 4, Queen Anne's-gate, S.W., have, with the sanction of the Metropolitan Board of Works, on the recommendation of Captain Eyre Shaw, C.B., Chief Officer of the Fire Brigade, arranged to provide, tentatively, six fire alarms in connection with the King-street Fire Station in that portion of the Western District which comprehends Golden-square, Piccadilly, Pall Mall, St. James's-square, Bruton-street, and Oxford-street (near the Pantheon). The apparatus supplied by Messrs. Griffith and Co. is known as "Spagnoletti's System," which was exhibited at the International Electric Exhibition of Paris, 1881, and will, in the course of a few days, be placed in the streets above-named, under the direction of the Engineer in Chief of Her Majesty's Telegraphs. Mr. Spagnoletti's apparatus was illustrated and described in our issue for August 12, 1882, p. 296, of Vol. IX.

Great Northern Telegraph Company.—According to the accounts of this company for the year 1882 the traffic receipts have brought in £239,864; interest, £8,181, and sundries, £8,810, which, added to a balance on the 31st December, 1881, of £19,689, brings up the total receipts to £276,544. The expenses during the year were distributed as follows:—Salaries and wages, £35,678; expenses of stations, offices, and agencies, £10,182; supervision and maintenance of sea and land lines, and repairing steamers, "H. C. Œrsted" and "Store Nordiske," £9,637; instruments and cells, £1,966; maintenance of buildings, £529; travelling expenses, £651; which, with sundry other minor expenses, made up a total of £71,214. The company paid 5 per cent. on 150,000 shares, = £75,000, and 3 per cent. as an extra dividend on the same number of shares, = £45,833, or a total of £120,833. They added £55,555 to the reserve fund, and £1,111 to the pension fund; paid, £1,500 in directors' fees, and carried forward a balance of £16,579.

Improvements in Secondary Batteries.—According to Patent No. 2602 (June 2, 1882), taken out by Sir C. T. Bright, the inventor divides each cell of his battery into two parts by a porous diaphragm, each part being filled with a number of leaden granules and dilute sulphuric acid. Leaden plates are placed in each part of the cell. Another part of the invention consists in covering the surface of plates with dioxide of lead by first exposing them to the warm vapours of acetic acid and carbonic acid gas, thus converting the outer surface into carbonate of lead, and afterwards treating it with chlorine gas. Another improvement consists in mixing dioxide of lead in the form of powder with the leaden granules above described. According to another patent, No. 2658, dated the 6th June, 1882, the inventor, Mr. A. Muirhead, of Westminster, claims the preparation and formation of the metallic electrodes of secondary batteries by placing the plates in a vat, through which a stream of a solution containing lead is caused to flow, and then producing deposits upon the plates from the said solution by the electrolysis of the liquid.

Electric Lighting at Dewsbury.—A very successful exhibition of the electric light has just been brought to a close in connection with the new Dewsbury and District

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Infirmary. During the exhibition, which lasted over four weeks, the building was brilliantly lighted by arc and incandescent lights, which were supplied by the Yorkshire Brush Electric Light and Power Company. Both arc and incandescents were run on the same circuit from a Brush forty-lighter, driven from the shafting of a mill about 200 yards from the building. At the concluding *soirée* on Friday, the 13th inst., a lecture was delivered by Mr. W. Kingsland, A.S.T.E., entitled "Electricity, a new Commodity." The lecture was illustrated by many experiments with the electric light, and the transmission of power was also practically demonstrated, the current which supplied the lights in the building being exclusively employed for these experiments, thus demonstrating the ease with which it could be sub-divided and applied for a variety of different purposes simultaneously. The company have, we are informed, been much complimented on the excellence of their arrangements for lighting the building.

Royal Society of Edinburgh.—At the last meeting of this society Mr. G. C. Knott, D.Sc., communicated two papers—the first "On the Measurement of Resistance of Electrolytes," in which he described a new and simple method which he had devised for obtaining rough and fairly accurate measurement results; and the second "On the Electrical Resistance of Hydrogenised Palladium," in which he communicated results practically corroborating the prior observations of Professor Dewar, that the resistance increased proportionally to the charge. Professor Tait communicated the result of some further experiments made to determine the thermo-electric position of pure ruthenium. Professor Tait said that he would now, by means of pure iridium and pure ruthenium, be able at last to form the standard thermo-electric thermometer which he had been seeking for so long, which could be reproduced everywhere, and by which comparison could be carried out all over the globe. These two metals would give them a perfectly definite standard of measurement for the purpose of comparing the temperatures, especially very high temperatures, of melting bodies in furnaces, &c., for which they had no proper instrument so far.

Electric Lighting and the Corporation of Glasgow.—At the last meeting of the Corporation of Glasgow, the minutes of the Gas Committee were brought up. Amongst other things, the minutes stated "that the town clerk had reported that the Board of Trade had issued model clauses which they proposed to insert in all Provisional Orders for Electric Lighting powers. From these clauses it would appear that the Board of Trade intended to put Corporations in very much the same position as private companies, and, *inter alia*, to make it compulsory on Corporations, as well as such companies, to undertake very serious pecuniary responsibilities. A representation against that proposal had accordingly been transmitted to the Board of Trade on behalf of the Corporation of Glasgow, as well as of several of the larger towns in England, who were promoting similar Provisional Orders, but no answer had yet been received to this communication. In these circumstances the Town Clerk advised that, in the event of the Board of Trade refusing to grant a Provisional Order to the Corporation substantially on the lines indicated in the application which had been deposited, the Corporation should withdraw their application. They would then be left free to make any arrangements they might think proper with private Electric Lighting Companies for lighting, experimentally or otherwise, any selected portion or portions of the municipal area. The committee unanimously approved of that course, and resolved to recommend to the Town Council accordingly." The minute was approved.

Another Box of Mystery.—A correspondent of the *Daily News*, telegraphing from Vienna on Friday night (April 13), said:—"Yesterday experiments were made here with a new electric accumulator, which is alleged to be much cheaper and more effectual than Faure's. The inventor is a Viennese. He dispenses with a dynamo-electric machine. A lamp which has burned since last night is still alight." This is another of those mysterious telegrams which from time to time set the public in a flutter of excitement, only to let them down with a smash when fuller and more reliable information comes to hand later on. As to the accumulator being "much cheaper and more effectual than Faure's," we fail to see anything new in this. There are several answering to that description much nearer home than Vienna. "The inventor is a Viennese." That we can understand; but "he dispenses with a dynamo-electric machine" admits of so many different readings that we must confess to being completely puzzled by it. Does the author of the telegram mean that the inventor dispenses with a dynamo for charging his battery? If so, he has evidently solved the perpetual motion problem, for we cannot suppose that he intends to imply that the inventor charges by means of primary batteries. He surely cannot mean that dynamos are henceforth to be consigned to limbo, and, if not, what does he mean? Then, again, "a lamp which has burned since last night (Thursday) is still alight (Friday)"; that is to say, twenty-four hours. What kind of lamp? And was it fed by one or more cells? The telegram is so absolutely vague, and so very likely to mislead the public, that we think it would have been just as well not to have published it.

Vienna Electrical Exhibition.—We have received the following official communication from the Science and Art Department, relating to the reduction in the Austro-Hungarian railway rates in connection with this exhibition. From this document it appears that (1), on goods sent per package the rate to Vienna and back will be 0·16 kreuzer per 100 kilograms per kilometer plus 2 kreuzers terminal charges (equivalent to a reduction of 70 per cent. on the usual rates). (2.) On goods sent per truck load to the exhibition the rate will be 0·13 kreuzer per 100 kilograms per kilometer to Vienna and back, the freight being for the actual weight with a minimum of 5,000 kilograms per consignment and truck load. (3.) The rates specified under 1 and 2 are through rates from place of receipt to place of delivery. (4.) Subsidiary charges, exclusive of terminal charges, will be according to the various tariffs of the lines concerned. (5.) Insurance of objects sent to the exhibition is granted as an exception to the usual rule on the matter. These facilities are only good during transit from Austro-Hungarian stations to Vienna and *vice versâ* and under the following conditions:—(*a*) Besides the way bill, consignments must be accompanied by a certificate issued by the exhibition committee giving the name of the sender and a list of the articles sent. (*b*) Goods are to be sent back by the route they came. (*c*) The way bill accompanying goods on the return journey must have annexed to it the way bill which accompanied them on the journey to Vienna; these two way bills must be further accompanied by a certificate from the exhibition to the effect that the objects were duly exhibited but were not sold. (*d*) There must be no charges "contre remboursement" on the goods either to or from Vienna. (*e*) The goods must go by goods train; if sent by passenger train (as express goods) the full rates will be charged. The organising committee at Vienna inform us

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that small iron cases will be provided in the machine room, in which visitors may enclose their watches whilst inspecting the dynamos, &c., in order to avoid their being magnetised and so stopped.

Siemens's Regenerative Gas Lamps.—Last week we referred to a report from Colonel Haywood, engineer to the Commissioners of Sewers, on the lighting of Fleet-street by Sugg's improved gas lamps, in which he gives some figures relating to the cost of this improved lighting. In another part of the same report Colonel Haywood deals with Siemens's patent regenerative burners, which have for some time past been used to light the city end of Holborn. Referring to the report we find that the illuminating power of each lamp is stated by the company to be equal to 130 candles. No photometrical observations have been made by the Commission to test their illuminating power. The ordinary 5ft. batswing burner should produce a light equal to about 14 candles. The illuminating power claimed for the new lamps is, therefore, 9·28 times that of the ordinary lamps. The relative costs of lighting the thoroughfare of Holborn appear to be as follow:—By the ordinary system the cost of each lamp, including lighting, extinguishing, &c., was £4 10s. 4d. per annum, or a total charge of £99 7s. 4d. per annum for the 22 lamps; this is exclusive of the lamps on the urinal in the centre of the carriageway. By the new system the cost, as given by the company, is 103,200 cubic feet of gas per annum at 3s. 2d., £16 6s. 10d.; lighting, extinguishing, and maintenance per lamp per annum (estimated by company), 18s. (the Gas Light and Coke Company estimate the cost of lighting, extinguishing, and maintaining these lamps at £3 each per annum); total per lamp per annum, £17 4s. 10d.; total for 22 lamps per annum, £379 6s. 4d. The expense by the ordinary system being £99 7s. 4d., and by the improved system, £379 6s. 4d., the latter is, therefore, 3·81, or about $3\frac{3}{4}$ times as much as the former. The general result appears to be that the lighting with Messrs. Siemens's regenerative burners gives more than nine times as much light as the ordinary street lighting, and at about $3\frac{3}{4}$ times the cost.

Telephone Wires in Bradford.—We make the following extracts from a report on the over-house telephone wires in Bradford (Yorkshire), made by Mr. John Walsh, of Stretford, Manchester, to the Corporation towards the close of last year, which, though not new, is interesting. Mr. Walsh began by referring to a previous report made on the 18th April, 1882, in which he laid down certain conditions which should be observed in the erection of over-house wires. These conditions were:—"1. That wires should cross streets at right angles, and be 'shackled off' at the supports. 2. That wires should not be suspended across open spaces, but that they should follow the lines of the buildings. 3. That poles well set in the ground and stayed should be used as supports for the wires where possible. 4. That attachments to chimneys should be avoided. 5. That wires crossing streets should not be less than thirty-five feet from the ground at the lowest part of the span. 6. That spans should not exceed as a rule 100 yards, with galvanised iron wire of No. 11 gauge, this being the wire with which the existing telephone lines have been constructed," Mr. Walsh then went on to point out certain lines belonging to the National Telephone Company which did not comply with these conditions, and which required attention. The chief alterations advised by Mr. Walsh were that some of the spans—one was 200 yards long—should be shortened, that phosphor bronze wire should be substituted for No. 11 galvanised iron wire, crossings made at right angles, and poles substituted where possible for standards on buildings. These alterations were carried out by the company in such a way as to enable Mr. Walsh to conclude his report as follows:—"In conclusion, I should like to be allowed to say that so far as I have been able to see, the Telephone Company have very fairly complied with the requirements of your committee as regards the lines they have re-constructed. Phosphor bronze wire is very well adapted for telephone over-house lines, because of its lightness and great tensile strength, and I am personally in favour of it, but there has not been yet time to test its behaviour in very frosty weather, but still I am sanguine of its being all right. Its lightness is its great recommendation, because in case of breakage there is not so much danger as there would be with No. 11 iron wire."

Electric Lighting in the House of Commons.—In the House, on Tuesday night, the following interesting little palaver was carried on. To begin with, Lord R. Churchill asked the First Commissioner of Works whether the Edison Company had lighted the dining rooms and smoking rooms of the House of Commons at their own expense, free of any charge to the public; and whether he would undertake that before any further arrangements were concluded for the lighting by electricity of the Houses of Parliament, or of any part of them, the business should be open to tenders in a manner similar to all other Government contracts. Mr. Shaw-Lefevre replied that the Edison Company offered to light the library and dining rooms of the House of Commons at an expense somewhat less than the cost of the gas which would have been consumed in the same time—an amount under £100. He thought that it would, on the whole, be in the interest of members to try the experiment. There was no further obligation to the company. He proposed before the end of the Session to consult the opinion of members as to whether this system of lighting should be permanent or not. If permanent, he did not think, from his experience of electric lighting, that it was a proper subject for competition. Lord R. Churchill asked whether it was not the case that the Edison Company had, for a considerable time, been lighting the General Post Office, with a satisfactory result; and whether, before the Law Courts had been lit by the Swan Company, the Messrs. Siemens, the Edison, and other companies had tendered, but the Swan Company was selected. Mr. Shaw-Lefevre said in answer:—I received no tenders from any of the companies named. After careful inquiry I invited the Swan Company to tender, and I accepted their tender. The Edison Company had lighted the Post Office, and it was mainly in consequence of their success there that I accepted their suggestion to light the library and dining rooms of the House of Commons. Lord R. Churchill then gave notice that he would call attention to the subject on the vote for the Houses of Parliament. Viscount Folkestone interposed here with: Does the hon. gentleman intend to extend the electric light to this chamber, and will he consider the desirability of substituting the electric light for the gas lamp on the Clock Tower? To which Mr. Shaw-Lefevre replied: I have no such intention. Mr. Alderman Fowler thereupon asked the somewhat facetious question: Is the hon. gentleman aware that the light on the Clock Tower went out the other night? Though it provoked some laughter, the House were apparently left in doubt as to Mr. Shaw-Lefevre's knowledge on this point.

The Patent Laws.—On Wednesday night Mr. H. Trueman Wood, secretary of the Society of Arts, read a paper before that body, in which he dealt with the three Bills for the amendment of the Patent Laws now before the House of Commons. One is the society's own Bill, another that introduced by Mr. Anderson, and the third that brought forward by Mr. Chamberlain. The first of these, Mr. Wood

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stated, had been fully discussed in that room; the second he characterised as being put forward "rather to represent the views of its originators than with any serious idea of its passing into law," and it was, therefore, wholly to the third, or Government Bill, that he directed his attention. Before analysing this Bill, however, Mr. Wood gave a sketch of what our system of granting patents ought to be. "Briefly stated," he said, "the object of a perfect patent system should be to encourage invention, by holding out sufficient, but not excessive, rewards to those who make useful inventions; to secure to the public the full benefit of inventions, both during the period of protection and afterwards; to stimulate progress in the application of all knowledge to useful purposes, by taking care that information as to what has already been effected is readily accessible; and to do all this in the simplest, clearest, and easiest fashion, at the least cost of time, trouble, and money to the inventor and to the public. Unless the present Bill can be shown to do all this—unless it is found to reach the high standard which can legitimately be applied to it—it would be better to let it follow the fate of its numerous predecessors, and to wait yet another year or two for the reform so often asked for, and so long delayed. It is the object of the present paper to try and ascertain how far the present measure will satisfy these legitimate aspirations; or, at all events, to put the matter before you in such a form that a discussion upon the Bill may afford some information to those members of Parliament who are interested in the matter, and especially those forming the Committee which has the Bill before it, as to the views of a meeting specially qualified to deal with this complicated question." Mr. Wood then proceeded to consider the different heads of the Bill, to point out its shortcomings and suggest amendments, devoting the larger portion of his paper to the consideration of "Applications for and grant of patents." In conclusion, he said:—"If I have devoted the main portion of my space to the enumeration of defects, I may remind you that the object of a paper like this is to draw attention to faults, with a view to their removal. Gratitude for favours received must be assumed, even if it be not expressed. On the whole, I think it cannot be doubted that the Government Bill is defective in many important respects, and requires careful amendment in committee. The machinery is inadequate, many parts of it would prove unworkable, and some others, it can hardly be doubted, would not work in the way which it may be assumed was intended by its framers. It is, however, certain that Mr. Chamberlain, and those with whom he has acted, are anxious to do the best they can to improve the law, and there need not, I think, be much fear but that they will listen to any suggestions for the improvement of their measure, and will give those suggestions such attention as they may think they deserve. I cannot conclude without expressing my personal indebtedness to the members of the society's patent law committee, and especially to two of them, Sir Frederick Bramwell and Mr. Alfred Carpmael."

Electric Lighting at the Manchester Exhibition.—The Members of "The Joule Club," a new scientific association recently formed in Manchester, held a meeting last week at the Manchester Electrical Exhibition, when Mr. Heys read a paper descriptive of some of the exhibits and also giving a rough outline of the principles of the dynamo as illustrated in a few typical modes of construction, the storage of currents, and the methods of distribution and illumination. In the application of electricity for general purposes, Mr. Heys said, we were at once faced with a difficulty. The current could only be distributed economically at a high difference of potential, or as it was now called pressure, but in our houses such a current would be highly dangerous. How to reconcile these requirements had puzzled many inventors. Mr. Edison had not got an accumulator of his own, and he had very lately derided their use, but as he saw Mr. Edison had a few days since taken out a patent for one of these delusions, he supposed he was beginning to think like other people. To meet the difficulty, and the certainty of a far higher pressure current in the future, a local system of distribution would be necessary. Let them suppose that their water service in the streets was laid at 700lb. pressure. It was certain that their house-service fittings would be in continual danger; but let them take the 700lb. pressure to a cistern at the top of a house, and draw the supply from the cistern, and they would be safe. Just so with electricity; substitute for the cistern storage batteries, and the parallel was complete. Of course there need not be a battery for every house, but for every convenient section. With regard to the question of safety, Mr. Heys said that if the leads or wires of a system were of sufficient capacity, there was no fear of their heating, and this was a point to be ever borne in mind. Roughly speaking, they might say that for every 800 amperes strength of current there should be one square inch of copper in the conductor. But there were other dangers besides heating the wires. If an electric light circuit were broken either purposely as at a switch, or cut out by the breaking of a lamp, or by accidental severance of wire, an arc would be formed capable of firing some substances. This might be prevented by care to some extent, for example, by using safety switches or cut-outs, and by employing care in the erection of the lines. For this work none but competent and experienced men should be employed. Circumstances might, however, very easily arise, as, for example, from short circuiting or an accidental joining over of the lead and return wire, or from the sudden turning off of a considerable number of lamps, when the amount of current will be too great for the safety of the lamp, if not for the conductors. To meet this, safety plugs of lead wire were employed. These melted quickly under the heat of the increased current, and so broke the circuit before any damage could be done. Taken altogether, he maintained that there was very much less danger with a good electrical system than with gas, and far more satisfaction. Having entered into a detailed comparison of the Swan and Edison lights shown in the exhibition, Mr. Heys called attention to several exhibits shown by Messrs. Pike, Sanderson and Pike, including an electric exploder for firing shots in mines; a signal for mines by which an alarm could be sounded simultaneously at both ends of the circuit by any one in the galleries of the mine simply pressing together two wires, and an apparatus by means of which engines could be stopped at once from any part of the works. In conclusion, Mr. Heys briefly touched upon the subject of electric motors. A dynamo electric machine, he said, when it was included in an electric current derived either from a battery or from another dynamo would revolve its armature rapidly, and drive any suitable mechanism with which it might be connected. Of course they might easily understand that a little rearrangement of the brushes was required to give them the necessary amount of lead, because, when driven by current, or, more properly, when driving, the armature revolved in the opposite direction. He exhibited two types of motor, the Griscom and the De Meritens, which were employed driving appliances in the exhibition—one in connection with a mechanical stoker and the other a sewing machine, and both actuated from the storage batteries of Electrical Power Storage Company.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XX.

We have now to consider the operation with reversed charges alluded to in the last number, without which the use of the electrometer for measuring insulation resistance would be imperfectly treated. We have thought it necessary to give two or three examples of this kind of test, and shall take the opportunity of carefully explaining the principles at work, believing that the matter to be gone over in this part of the subject will furnish opportunity for getting a clear insight into details and points which are likely to occur in other branches in practice, about which learners are often confused, not understanding the principles on which they act mechanically. The test now before us is illustrated in Figure 43, where we have the connections necessary for its operation. We have a double current battery key for sending different charges to line (or cable), also a slide resistance scale with one battery pole at each end, as in the last test, and one end to earth; the lead from this arrangement connects with another double current key, which is necessary for reversing the connections with the electrometer quadrants when the battery key is reversed; the cable is joined to either bar of this key when the adjacent plug

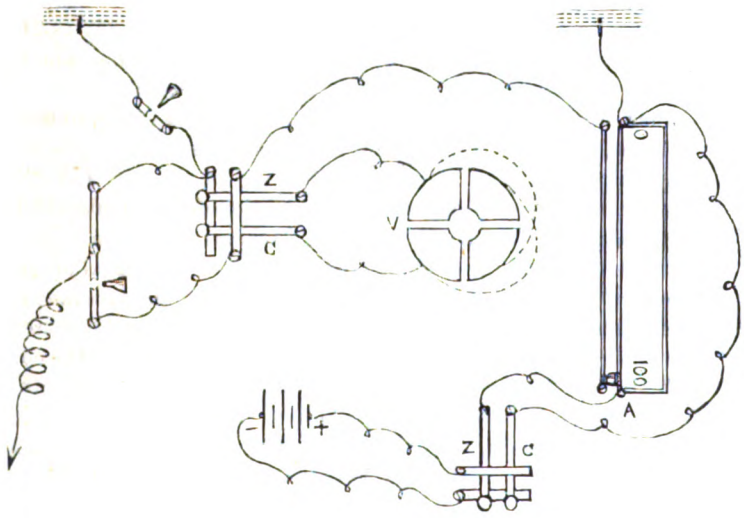

FIG. 43.

is inserted. This plug answers the purpose of bringing the cable and both pairs of quadrants under the influence of the charge when in its place, and when removed leaves one pair connected with the cable and the other with the battery. The cable can be put to earth if required by the other plug, and the electrometer can also be earthed by a third plug not shown in figure. The arrangements might have been varied, but we have here a plan of connections used in practice for a considerable time, and one which was found to answer all requirements perfectly well. It will be noticed that we have a slide resistance, whilst in the previous test we had a set of coils without a slide and scale. Either plan will answer both purposes, the difference being compensated for by an alteration in the other appliances. In the present operation the inferred zero would be taken by pushing the slide down to figure 10 on the scale, when the potential of the charge would be one-tenth of the whole. We have marked only two places at the several extremities, the potential when the slide is at A being 100, and decreasing down the scale to 0. The slide takes up and conveys to line through the lower bar the potential at whatever place it may be fixed, as the charge passes to it through whatever number of resistance coils are marked off. The two keys are similarly marked Z and C, directing the change of battery poles for charging the cable and the alternate pairs of quadrants. One hundred cells will be used, and it is very desirable to give attention generally to the state of the battery, which should be well insulated by hanging shelves or insulating trays or feet to the stand, and kept clean and free from damp on its shelves and the surface of its jars. It is assumed that the cells are all equal. The spot of light will be made (by using the micrometer screw) to fall on the end of the scale next the operator, supposing the electrometer to face it, so that the former is at right angles to his position at the table. This applies to both of these tests. As regards the limits of time fixed for the reading of the deflection, there is some difference. In the previous test we supposed the state of the cable to be noted after two minutes' total leakage; the close of the 30 seconds completed the two-minute test; and a five-minute test is also often taken in the same way by merely allowing the cable to continue leaking after the two minutes till 4′ 30″, when a reading is taken, and again 30 seconds later. In this reversal operation the cable is first charged, say with zinc, for 15 seconds, and then allowed to leak for a shorter period than 90 seconds, and after one or two readings at short intervals the charge is reversed, and a repetition of such charges is made for a certain time fixed by the electrician in charge. We do not think we ought to go through the test exactly as it has been done in practice; that is to say, as regards the particular intervals and periods of reversals. It is one devised by Sir William Thomson for his own testing room in the case of a well-known cable, and we do not like to publish it without his express permission. It will be quite sufficient to give an imaginary set of periods for charge and leakage, and, as bearing on a practical operation, the course may be usefully followed, though the details are not the same as Sir W. Thomson's.

The inferred zero will first be taken (with both positive and negative currents if desired) by using the slide as above suggested and multiplying the reading by 10. This should be done before joining up the cable, which latter (arrow pointed) will now be connected at the bar and the plug inserted. It is best to commence charging at the full minute, and, if there is no stop watch at hand, to start at 5, 10, 15, &c., minutes past the hour. We will first clamp down Z in the electrometer key, and then do the same with Z in the battery key, the slide being close up at the battery end, as in the figure. The negative charge now enters (technically speaking) the cable and both sets of quadrants. After 15 seconds the plug is taken out, when the cable and one pair of quadrants remain connected together but free of the battery charge, and the other pair continues under charge. We will suppose the cable to leak for sixty seconds; we then read the deflection, and again after one more minute's leakage; we then replace the plug and proceed to reverse. In so doing we must first release Z in the electrometer key and at once clamp down C, and then do the same with the battery key, but noting the time so as to charge the cable with the opposite charge for fifteen seconds. After this period the plug is again removed and readings taken at the same intervals as with the zinc charge. The operations can be repeated as often as may be necessary, and at the end of the test the cable will be put to earth or removed, the keys being first released, and the electrometer also put to earth if required. The object of the electrometer key in the test in one respect is for securing the passage of the spot always in the same direction along the scale, which can only be done by alternating the charge in the quadrants. We shall not go further into this particular test, but may observe that the learner should particularly avoid being flurried or over anxious about the passage of time, as regards the intervals between reading and charging, &c. Beginners at this work always imagine the seconds pass much faster than they really do, and from uncertainty in this matter work themselves up into a state in which they lose their presence of mind, and miss the readings altogether. It surprises them after a little practice to see how much can be done in even 30 seconds. They may learn the value of time in this way, if they gain no other advantage.

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We will now turn to the working out of this kind of test, whether taken with the electrometer or the galvanometer, though, perhaps, more particularly with reference to the former. At the close of the last number we stated that the test was independent of the length of the cable. This would refer to the resistance per unit of length or knot. The calculation can be made either way, using either the capacity per knot or the total capacity in the working out. Let us look at the matter a little closer than we have yet done. If our operation is made with reference to a knot-length of the cable under test, all the conditions are taken in relation to this length. We have also the conditions of capacity to consider, that is, the charging capacity per knot of this particular cable. In connection with this is the specific capacity of the insulating material, since insulators differ in this respect according to their nature. But unless one kind of insulator is to be compared with another, we need not regard this point in what we are now doing. The condition is involved in the value for capacity which we employ in the formula. The reader will see clearly why the quality of capacity forms one of the conditions governing the calculation of the insulation resistance, because the action resisted is between two opposed conducting surfaces (the copper conductor and the sheathing or earth) and the accumulation must influence the state of affairs favourably or otherwise as it is great or small. Now we have a body, that is a cable of a certain charging capacity charged to a certain potential, or charged to an extent which we have estimated by the number of divisions on a scale which the charge would cause its index, the light, to pass over if all ran out. We may say that the charge was one that would embrace a sweep of 4,875 divisions. It will be remembered that this is the first of the two boundaries, so called in our last number, between which we have an interval of 30 seconds. This amount, then, we may call the potential of the cable at the commencement of this period. The cable loses its charge gradually and falls in its potential from 4,875 to a potential represented by 4,825 in 30 seconds. This discharge takes place against or through a resistance (every action or effort is one opposed by a resistance) which is that offered by the dielectric separating the conductor inside from the earth or water outside. This resistance in the first place will vary directly with the time during which it is in force, or, in fact, during which we limit its consideration. The longer it acts the more of it there is. It will vary *inversely* as the charging capacity of the cable which would, as before suggested, favour the condition through the dielectric—the greater the charging capacity the less the resistance, and *vice versâ*. We have further to consider the rate of discharge, which is a ratio that is also *inverse* to the resistance under notice, because the faster the cable discharges the less it affords resistance to discharge, and therefore the percentage of leakage holds the same relation to the resistance that is given by the capacity. This statement is to be taken as *generally* true, that is to say, it is a part of the truth the exactness of which is expressed by an addition to it. We will endeavour to explain the apparent anomaly by reminding the student that we have to specify the conditions we are discussing by representing them as values. The percentage of discharge is truly a ratio, but when we come to apply it as a value, we must take it, not simply as a ratio, but as the logarithm of a ratio. This point in the conditions governing the formula is the only one now presenting any difficulty, and must be briefly examined.

Of course, the reader knows that compound differs from simple interest in the fact that the interest at each term is calculated on the sum of the capital added to the previous interest, as, say, the interest on £100 is 5 per cent. per annum. Then £5 is the interest for the first year. This is added to the £100, and the second year the interest is 5 per cent. on £105, and so on. Take the converse of this, and suppose 5 per cent. to be deducted every year on the principle of compound interest. Then out of £100 £5 would be deducted the first year, and the balance £95 is the sum on which the interest is calculated for deduction the second year. It is in analogy with this latter course of operation that we find the fall of charge in a submarine cable. For, as stated above, if 5 per cent. of the charge escapes in the first minute, 5 per cent. of the remainder would escape in the second minute. The resistance of the cable is small or great as the rate of interest is high or low; and, as in a money transaction, it may be estimated as favourable where the accumulation is rapid, because the amount in each year is much increased. So with a cable, it is a good one (in the sense of being well insulated) if the amount is but slowly *decreased*. We have the capital, the rate of interest, and the amount. We have already suggested the illustration of the escape of water from a cistern. The ratio $\frac{800}{400}$ then mentioned gives in reality the rate of interest—if the amount at the first period is double that at the second 50 per cent. has escaped. Returning to the money analogy, the amount of £100 may be taken to represent the first reading, and £105 the amount or principal at the end of the year for the second reading. Then the ratio $\frac{100}{105}$ represents the rate of interest, for the original capital is increased by £5, or one-twentieth of its amount, and as 100 : 105 :: the capital : $\frac{100}{105} = \frac{20}{21}$, and 20 is increased by one part. The case of the cable losing its charge is the converse, and the ratio, composed of two readings subtracted from zero, gives us the rate of interest which could be expressed in percentage form. Thus the ratio $\frac{4875}{4825}$ is the exponent of the rate of decline of the charge, as the ratio $\frac{100}{105}$ declared the rate of interest in the money example. Now we took the fraction $\frac{20}{21}$, and found the rate of interest by seeing how many units more there were in the denominator than in the numerator; it is one-twentieth, or 5 per cent. In the cable fraction the denominator is the smaller because the operation is a decline instead of an increase. There are 50 units out of 4,825, and this is for the half minute; it amounts to about 3 per cent. per minute, an imaginary quantity not claiming to be the true standard for cables.

The only point now remaining is the fact of using the ratio or $\frac{P}{p}$ as a logarithm, and the actual proof by figures is out of our province, but to any reader who may not be acquainted with the rules for calculating compound interest, we can only say that the terms of this ratio correspond to the amount and principal in that calculation, and in the course of making a rule for general application, in which algebraic symbols are employed, the relation or inter-multiplication of these results is a combination which can only be correctly expressed by a logarithmic statement. Then, in working the formula given in a recent number, the insulation resistance will be obtained in this way. As several different cables are tested every day, and each will probably have a different capacity per knot, every device which minimises the labour of calculation is desirable. The capacity forming a part of the formula $R = \frac{26{\cdot}06 \times t}{F \log \frac{P}{p}}$ and having to be divided into the numerator, there would be a succession of calculations, but a constant value is found for each cable, which has only to be divided by the $\log \frac{P}{p}$ to give us the resistance per knot in each case. The value 26·06 is constant, as is also the 30 sec., the time can be worked either in seconds or minutes—the latter is preferable, therefore the value for t will be ·5. That for F, the capacity per knot, will vary in each cable. We will suppose a figure, say, ·333. Then 26·06 × ·5 and ÷ ·333 will give us a constant for that particular cable. It is usual to work by logarithms, which can very easily be picked up by those who are not acquainted with their use. From the logarithm of the constant will be subtracted the

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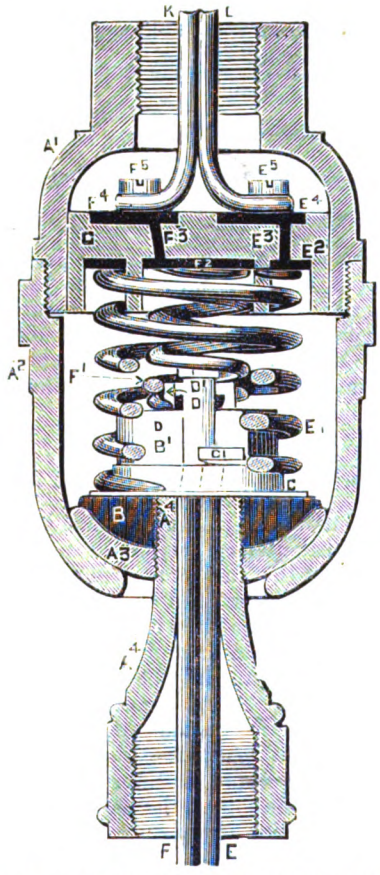
logarithm of the log $\frac{P}{p}$, and in working out the beginner must be careful to put always the characteristic to the logarithmic value, and in re-converting the logarithm to its natural number to render the figures correctly. Also not to forget that the ratio $\frac{P}{p}$ is already a logarithmic value. In using it we must first find the logarithm of P, and from this subtract the logarithm of p. The result is a logarithm, of course, but we must treat it as a natural number and find its logarithm again, then subtract this from the logarithm of the constant. The full natural number of the remaining logarithm is the insulation resistance per knot in megohms of the cable. In the article on the working out of tests we shall furnish an example of this, as of other calculations.

VERITY'S CUP AND BALL JOINT FOR ELECTRIC LIGHT PURPOSES.

We are glad to see the manufacturers of gas fittings turning their attention to the requirements of the electric light. Messrs. Verity and Sons were amongst the earliest, if not the earliest, of the manufacturers to recognise that business is

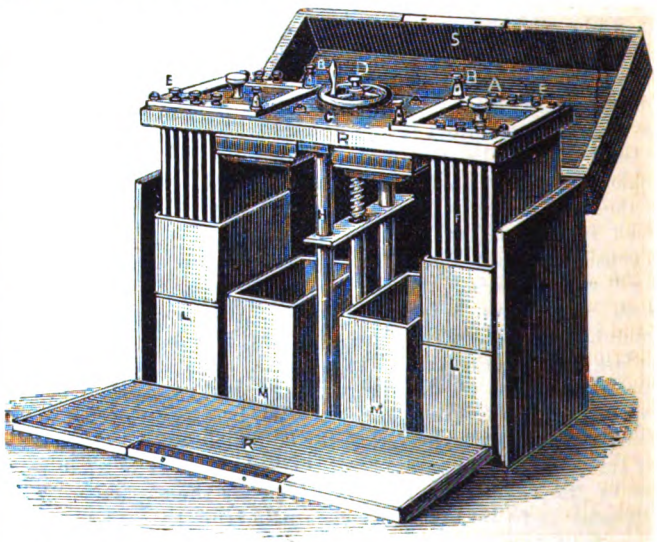


Verity's Cup and Ball Joint for Electric Light Purposes.

not exclusive, and that the practical knowledge already obtained might be of great service in designing apparatus for the newer industry. They, therefore, attempted to make themselves conversant with the requirements, with what success is known by the general appreciation of their productions at the Crystal Palace last year. A more recent introduction is the cup and ball joint, which we now illustrate. The parts A^1, A^2, A^3, A^4, shown in section, are similar to the usual ball and socket arrangement, the part of the ball A^3 rotating in the cup A^2. On the end of A^4 is screwed a piece of vulcanite, B B^1, for insulation, to which the rings C D are fixed. The insulated wires E F from the electrolier are carried through the tail piece A^4 to the rings C D, and contact with them is made by the screws C^1 D^1. The two helices E^1 F^1 are made to tighten on to the rings C D respectively, and to make good contact with them. All the parts where good electrical contact is required are turned over to prevent bad contact from oxidation of the parts. The tops of these helices are flattened and press against the plates E^2 F^2 fastened to the vulcanite part G. These plates are again connected by the conducting wires E^3 F^3 to plates E^4 F^4 respectively. To these latter plates the insulated wires K L are brought through the neck A^1, and connected by means of the screws E^5 F^5. From this it will be seen that when the electrolier is swung the flattened top of the helices are always electrically connected with the plates E^2 F^2. Experience has taught the necessity of using a metal for the helices having somewhat the springiness of steel and the conductivity of copper, and, after a number of trials, phosphor bronze was found the most suitable metal for the purpose. The various parts are all carefully tested before leaving the factory, and a safe margin allowed in the construction for the current it is proposed to carry. A considerable number of these joints are in use, and found to act satisfactorily. As we have said, Messrs. Verity and Sons have given great attention to electric light fittings, have recently produced various improvements in such apparatus, and have shown sufficient confidence in the value of the light to have it installed upon their premises in Covent Garden, and we have no doubt they will be able to produce any kind of fittings the increased adoption of incandescent lighting may demand.

A PORTABLE BATTERY FOR MEDICAL PURPOSES.

The following form of portable battery for medical purposes has recently been devised by M. Chardin, a French



Portable Battery for Medical Purposes, designed by M. Chardin.

electrician. It is an ordinary bichromate battery, the zincs and carbons of which are fixed to a movable frame R, and so arranged that they can be inserted partly or wholly in the liquid, or removed therefrom as required. As will be seen on referring to the illustration herewith, the movable frame is raised or lowered by means of the screw D and its handle C, the guides H keeping it in position. When the battery is not required for use, the movable frame is raised until the plates are just clear of the top of the jars L. These are then put where the ebonite jars M are shown to be in the figure, and the jars M are placed where L are. The movable frame is then lowered, the plates going into the empty jars M, and the tops of the jars L, which contain the exciting liquid, being closed by the india rubber stoppers shown on each side of the letter R. The side facing the reader is then shut up, the lids clapped down, and the battery ready to be carried away. There are three zinc and four carbon plates in each jar, connected in multiple arc. B B and E E are the terminals connected with the plates.

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LITERATURE.

Electric Light: Its Production and Use, Embodying Plain Directions for the Treatment of Voltaic Batteries, Electric Lamps, and Dynamo-Electric Machines. By J. W. URQUHART, Electrician. Edited by F. C. WEBB, M.I.C.E. [Crosby Lockwood and Co.]

We have an intense dislike to the notice of technical books where a living author calls in the aid of an editor. Which of the two is to be praised for satisfactory work, and which is to be blamed for unsatisfactory work are questions we are unable to answer. Some years ago, during a conversation with an intimate friend, a partner in one of the leading publishing firms, the conversation glided into remarks upon successful books from a publisher's point of view. A special book was named as an example of a book compiled by a man whose ignorance of the subject was clearly shown by every page, whose correct paragraphs were simple transcriptions without acknowledgment from other authors, and who was evidently incompetent to decide which was correct and which was incorrect when both data lay before him. The book was attractively arranged by the printer, well printed, well bound, and issued at a low price, for all of which mercies it was said no thanks were due to the author. The book was said by the publisher to sell better than any other of the hundreds this firm published. The reason given for its extensive sale was that purchasers, being utterly ignorant of the subject, were induced to purchase by the look of the book.

The book before us is not a cheap book, yet one edition has sold. It is well printed, and presents an attractive appearance; but far be it from us to hint that its success is due to these features. A work of this kind — we write subject to correction — seems to require no author, only a competent editor. There is a minimum quantity of original matter, and a maximum amount of "edited" matter. In fact, it seems that the sole value of such a work — and this value is really considerable — is in the manner in which diffuse information to be found in papers to societies, in periodicals, &c., is condensed and edited. Theory is carefully avoided, but a concise description of all the well-known pieces of the electric light apparatus is to be found herein. This to us is the sole value of the work. Any one interested will find a short account—an account requiring no mental strain of the reader to understand—of the electrical productions for the last few years. Discrimination has been shown in the method of obtaining information, the sources to the initiated being easily traced—many, in fact, being duly acknowledged—and greater discrimination has been shown in the selection of Mr. F. C. Webb as editor. Some of the objectionable features of the first edition are found wanting in the new edition, but we yet think that sentences like the following in a work of such pretensions should be left out:—"The price of these machines, with the exciter, is from £170 to £535." Is there anything similar to this in "Rankine," or "Clerk-Maxwell," or "Tyndall," or generally in books claiming to be out of the class "price lists?"

We do not wish to be thought condemning books of this kind; our idea is that such works are valuable, but their value is not quite so high as the published price of this work implies. If we are asked to pay so much for second hand material, no matter how well compiled and edited, what is the value of a similar sized work which is the outcome of brain power in the shape of original thought? We have enough books containing mere descriptions, and we begin to ask, when is Professor Ayrton's promised book or Mr. Gordon's promised book to make its appearance?

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ending the 13th April, 1883, were £3,792.

MAGNETISM.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 528.)

11. *Magnetic Field.*—It is of great importance that this conception of a "field of force" should be thoroughly realised and replace the old fallacy of a repulsive *force* because this supposed force is very apt to mislead in many directions, and it is well to see that throughout all nature we find no trace of a repulsive force, and, therefore, ought never to apply the idea to any phenomenon merely because it offers an explanation. The action of magnets is the strongest apparent evidence for the existence of such a force, and this makes it the more desirable to show that no such force is necessary to explain the facts. Fig. 9 will convey the idea of a magnetic field, in end view and perspective. It shows the magnetic bar constituted of the annular (or spiral) systems of statically polarised molecules as in Fig. 8. These molecules manifesting magnetic force at right angles, and their actions uniting in the aerial line of the magnet and developing the lines of magnetic force as shown in the arrows; the external "field of force" is developed, under the general law of inductive action by circles of polarisation in the opposite direction to those of the magnet itself; the magnetic lines of force of these therefore attract, and form closed lines of force with those of the magnetised bar. The external arrows therefore show the position in which another magnet would necessarily place itself, *because in so doing the lines of force of the second magnet would place themselves in those of the principal field.* The lines of force of magnetism, like those of electricity, tend to the direction of most capacity, so that whenever a magnetised or magnetic body enters the field, the lines of force concentrate within it, and the external actions are to that

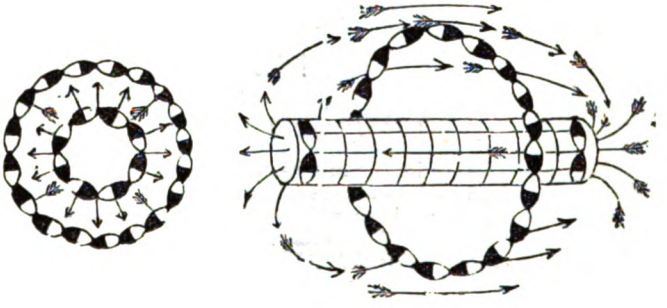

FIG 9.

extent suppressed. This is just what happens when an armature is applied to a horse-shoe magnet. In the case of a horse-shoe the external field forms itself in the space around the opening, forming an ellipse, with its circles of polarisation in the same order as those of the magnet (instead of reversed as in Fig. 9 where the magnetic lines have to return on themselves); on the approach of the armature the lines of force are taken up by the iron, which becomes itself a magnet forming a continuation and completion of the horse-shoe; the energy of the external field develops the force of attraction, and if the armature is sufficiently large and in very good contact, the magnet now ceases to have any external action, because its whole circuit is self-contained. This never occurs completely in the case of an armature, because perfect contact is not to be attained; but if a homogeneous ring of steel were magnetised it would show no external magnetic action. Such a ring would manifest opposite free poles of equal strength, at any point in which it might be cut across, and part of its energy would pass into the external circuit which would be then developed.

12. *Attraction and Repulsion.*—When the magnets approach each other they manifest *attraction* between unlike poles N and S and *repulsion* between like poles N N or S S. When a non-magnetised but magnetic body approaches a magnet it is always attracted, because magnetism is *induced* in it as just described in true polar order. If a weak magnet approaches a strong one, its magnetism may be overpowered by induction, either temporarily or permanently. *Repulsion*, however, is not due to any repulsive force between the poles; as with electricity, it is simply the reactions of the whole fields on each other and the endeavour to place themselves symmetrically.

Attraction is illustrated in Fig. 10, which shows the action of opposite poles approaching; the lines of the magnet and external fields of 1 and 2 enter each other and blend in one; they draw together just as do opposite electric charges, and the result is

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that the two magnets constitute one long one, in which the S N poles at the middle disappear, and their forces are transferred

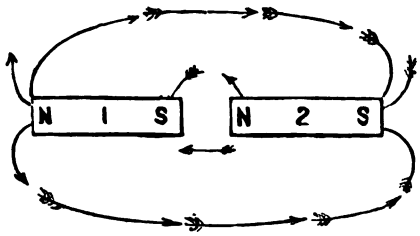

Fig. 10.

to the external poles, as when two Leyden jars or galvanic cells are coupled in series.

Repulsion is explained by Fig. 11, where 1 and 2 are magnets with like poles presented; at once the lines of 1 S and 2 N coalesce and tend to turn the magnets round, as will be readily understood from the drawing. If motion is only possible in the vertical line as shown, the magnets will recede from each other,

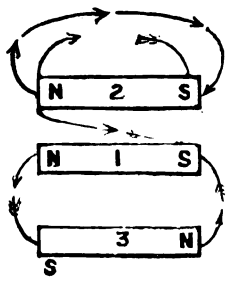

Fig. 11.

because each of them seeks to take possession of the molecules of surrounding air to complete its field, and therefore the magnets themselves move in the direction which involves the least resistance. Fig. 11 shows also another instance of attraction as between 1 and 3, where both poles act together, and each bar acts as the external field of the other.

13. *Mechanically Produced Fields.*—Fields of force such as are shown in these figures are not merely imaginations; they are capable of being visibly produced by mechanical means, and in them may be reproduced phenomena strongly resembling those of attraction and repulsion. The curious vortex rings formed of smoke issuing from an opening in a chamber subjected to a sharp blow (and resembling those often produced by cannon) are to some extent illustrations of this, for these circling rings possess many of the attributes of solid bodies, moving as a connected whole in space, and even rebounding from each other.

Dr. C. A. Bjerknes, of Christiania, exhibited at the Paris Exhibition of 1881 a series of experiments in which the motions of attraction and repulsion were very perfectly imitated by means of currents of water. The apparatus consisted of small drums connected to an air-pump which alternately expands and contracts the diaphragms. To give any intelligible explanations of the interesting experiments would occupy several pages, but the result is that if two such drums are placed in water so that one of them is movable, and a succession of pulsations imparted to the diaphragms, *attraction* occurs if both pulsate alike, but *repulsion* occurs if the pulsations are alternating.

Mr. A. Stroh, in a paper read to the Society of Telegraph Engineers, 27th April, 1882 (and which received the rare honour of repetition) illustrated the same principles applied to vibrations in air. His paper will be found in Vol. XI., p. 192, of the *Proceedings of the Society*, and in *The Electrician*, Vol. VIII., pp. 405 and 421, with numerous illustrations showing the effects produced. These show just such "fields of force" set up by pulsations in the air as are shown by iron filings in the case of magnetism.

14. *Laws of Magnetic Force.*—Many attempts have been made to fix the laws of attractive force of magnets, and the result appears to be that it varies inversely as the square of the distance, as it must indeed from the cause which generates this universal law of actions proceeding from a centre, this being a necessary consequence of the fact that the areas of spheres increase in that ratio; but this only applies to each point of a magnet regarded by itself. Practically no distinct law can be laid down, as the force is a compound action. It is not governed merely by the distance of the attracted body from the magnetic poles, but by the form of the acting "field of force" between the poles. It is, in fact, quite possible to make a number of magnets, all of equal power upon an armature in contact, yet all differing in their attraction for their armature at different distances.

15. Let us conceive two such magnets: A (N——S) with 1in. between its poles; B (N——S) with a space of 3in. It is evident that the field of A will be the more intense, but that it will extend only a small distance from the ends of the magnet; necessarily, therefore, the force of attraction on the armature will diminish much more slowly, as distance increases, in the wide magnet B than in the narrow one A. The real law is to be found, not in the distance of the armature, but on precisely the same principles as govern the relations of two derived inductive circuits in electricity. The magnet has, in fact, two circuits in which to close its lines of force. Fig. 3 makes this clear (*Elec.*, April 14, p. 526). If we consider N and S to be the polar extremities of the horse-shoe magnet, the magnetic field is shown by the curves, it being formed on the same principles as the electric field If we now imagine a bar of iron approaching from above, this, by its greater magnetic capacity, will draw the lines into itself, and two fresh fields will form between its extremities and N and S. It is evident these two fields are a pair in series, dividing the force with the original field in *the ratio of the several capacities*, which may be roughly considered as represented by the relation of the distance between N and S as against the sum of the distances N armature S. Here again it becomes obvious that no law based upon the mere distance of the attracted body without considering the form and conditions of the magnet, can possibly express the facts and forces.

It would seem, therefore, that it is a mistake to bring the poles of horse-shoe magnets near together; that they would do more work if the opening is wide, because when once in contact the length of the armature offers small resistance, if it be made of pure soft iron, while this form gives greater range of work.

The force exerted by a magnet holding up a weight is measured in dynes by multiplying the weight in grammes by g, the force of gravity at the place, which is about 9·81 in England.

16. *Magnetisation.*—Steel may have magnetic power developed in it by drawing a bar magnet along its several surfaces, always in one direction; it is still better to arrange a complete system of bars forming an octagon or square, and draw the magnet round and round, always in one direction. In this plan the bars may be all steel, or alternate steel and iron.

If the operator has two bar magnets, an excellent plan is to place them with opposite poles together over the middle of the bar to be magnetised, and then to draw them slowly asunder to the ends, repeating this six or eight times on each face. This process is still more effective if the ends of the bar rest on two

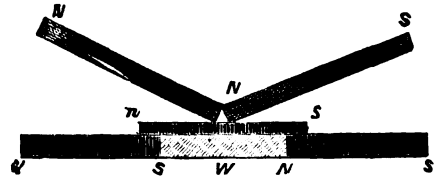

Fig. 12.

other magnetic bars with their opposed poles in the same direction as the moving magnets. Fig. 12 shows this process, N S being the bar to be magnetised and W a piece of wood to support it and steady the lower magnets. This is called the method of single touch, and is best suited to thin needles and bars not more than a quarter-inch in thickness.

The method of double touch may be illustrated by the same figure.

The triangular space between the two movable magnets is filled with a piece of wood, and their upper ends connected by a bar of soft iron, and both are moved to and fro along the bar N S, without separation. This process gives more magnetic power, but is apt to be irregular and to produce *consequent points*.

Horse-shoes should be magnetised on the same system: closing the poles with a soft iron armature, or a bar magnet properly placed, or two can be arranged facing each other.

The bar magnets may be advantageously replaced by electro-magnets which can be given a much higher specific magnetism than steel can retain; this is a great advantage because the magnet can generate no higher intensity than it possesses itself, and, therefore, the stronger they are the better they magnetise.

17. *The Battery Process.*—This is the most convenient. It consists in making the steel bar act as the core of an electro-magnet for a few seconds. A short coil should be made of stout

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covered wire, the central opening of which is large enough to allow it to be passed over the bar. It should be arranged at the middle of the bar, and connected to a battery sending a powerful current through it, and regularly passed along the length both ways several times, allowing the ends to half enter the helix, and brought back to the middle before the current is stopped. The action is facilitated by slightly tapping the magnet during the process to produce vibration. It is also found that an intermittent or breaking current is more effective than a continuous one.

The magnetising is also assisted by completing the magnetic circuit externally with soft iron. In this case also the magnetism retained is higher than if the steel is not provided with an armature to complete the magnetic circuit. The reason is that as in compound magnets, part of the lines are apt to return within the mass of the metal.

(TO BE CONTINUED.)

AN EPISODE IN THE EARLY HISTORY OF THE TELEGRAPH.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.

[We have been favoured with the following advanced sheets of a work which Mr. Fahie is getting ready for the press. It will treat of the history of signalling of all kinds from the very earliest ages down to the year 1837, the date of the practical introduction of the electric telegraph by Cooke and Wheatstone. Mr. Fahie requests us to say that he will be glad to receive communications or suggestions from any of our readers, as he is anxious to make his history as complete as possible.—ED. *E.*]

Twenty-five years ago, in the course of a research amongst the imperial archives at Paris, M. Edouard Gerspach, of the French Telegraph Administration, discovered some documents which, in our eyes, are of exceeding value as establishing for La Belle France the honour of the invention of the first step-by-step, or A.B.C., telegraph. These precious papers were embodied by M. Gerspach in a memoir for the *Annales Télégraphiques* for March-April, 1859, pp. 188-99, to which we are indebted for much of what follows in this article.

Jean Alexandre was born at Paris, the natural son, it is said, of Jean-Jacques Rousseau. He had the education of a mechanic, some say of a physician, but his actual career was truly a faithful image of the troublous times in which he lived. In 1787 he was at Poitiers, following the trade of gilder, and as he had a fine voice he sang in the churches, which added somewhat to his slender emoluments. But soon the revolution came to Poitiers, and swept away the *clientèle* of the poor gilder and carver. His occupation, like Othello's, was gone. He went to Paris, and there maintained himself for a while by singing in the choir of St. Sulpice; but the revolutionary tide followed him, and closed the doors of St. Sulpice as of all the other churches, leaving Alexandre high and dry again, without the means of subsistence.

Feeling there was nothing else to be done, he now took to politics, and, after the manner of the times, soon found himself president of a section of the Luxembourg (club), and later on a deputy of the Convention. This latter honour, however, his simple manners made him decline. But greater honours still were yet in store, and as he was preparing to return to his workshop at Poitiers the Government sent him thither, but with the exalted rank of Commissary-General of War. Later on he was promoted to be chief of the military division of Lyons, where he had to organise an army of 80,000 men. With the title of Chief Agent of the Army of the West he next went to Angers, where, from the forty-two departments that were under his orders, he had to raise another army of 200,000 men (!). With all this greatness, he still was not happy; he yearned for a quiet life—a feeling which seems to have grown daily stronger with him, until, at last becoming irresistible, he quitted honours and politics, and returned to his home at Poitiers, as poor as he had left it—a fact, by the way, which speaks volumes for the integrity of his character.

Here we find him in 1802 producing his *télégraphe intime*, or secret telegraph. He wrote to Chaptal, Minister of the Interior, acquainting him briefly with the discovery, and asking assistance to enable him to go to Paris and exhibit his machine to the Government. The Minister asked (and naturally) in the first place for full particulars and plans of the apparatus, but Alexandre declined to divulge his secret, and addressed himself next to Cochon, Prefect of Vienne, offering to make an experiment before him. The Prefect, agreeably impressed with the conversation of the inventor, whose quick and vigorous imagination he found to contrast singularly with the simplicity of his demeanour, granted his request, and accordingly on the 13th Brumaire, year X (early in 1802) he went, accompanied by the chief engineer of the department, to Alexandre's house. The experiments were crowned with unhoped-for success, and the Prefect drew up a report for the minister, Chaptal, of which the following is the substance:—

"We were conducted into a room on the ground floor, in the centre of which we found a box nearly 1·5 metre high, and about 30 centimetres broad and deep. This box was surmounted by a dial, around which were traced all the letters of the alphabet. A well-poised needle or pointer travelled round the circle at the will of a distant and invisible agent, and stopped over such letters as composed the words that he wished to communicate. The completion of each word and phrase was indicated by an entire revolution of the pointer, which in its normal state of rest always occupied a certain determined position (corresponding, no doubt, to our zero).

"A correspondence was established between the (distant) agent and ourselves, and the success was all that we could desire. The dial repeated exactly all the phrases that we had dictated, and the (distant) agent added some from himself, which we had no difficulty in understanding. On asking why the second box was situated in an upper story, about 15 metres distant, instead of being placed on the same level as the first, the author replied that it was to show that difference of level had no effect on its action, and that the conductors could in every case go up and down, and adapt themselves to the inequalities of the ground.

"We understood, without, however, his distinctly saying so, that the author derives his power (*usage*) from some fluid, either electric or magnetic. He told us that in the course of experiment he had met with a strange matter or power, of which, until then, he had been ignorant, but which, he was almost tempted to believe, is generally diffused, and forms, in some sort, the soul of the universe; that he had discovered the means of utilising the effects of this power, so as to make them conduce to the success of his machine; and that he was certain of being able to propagate them with the celerity of light, and to any distance that may be required."

In concluding this report on the invention, which the Prefect characterised as a work of genius, he urged that Alexandre should be called to Paris, at the expense of the State, in order that he may repeat his experiments under the eyes of the Government. The minister, Chaptal, did not, however, regard the discovery at all so favourably, evidently imagining it to be a telegraph of the Chappe or semaphore kind, and wrote to the inventor's agent, declining to have anything to do with him. Such a rebuff would have acted as a *quietus* to ordinary people; but inventors are proverbially a tenacious race. Alexandre was an inventor, and, firm in his convictions, he quitted Poitiers, and in hopes of better fortune, betook himself to Tours.

There, at his invitation, General Pommereul, Prefect of the Department of the Indre and Loire, and the mayor and officers of the city of Tours, assembled at his house to assist at a public trial of the apparatus. As before, one of the machines was on the ground floor, and the other on the first story, separated from the lower room by an ante-chamber and a small court. The Prefect dictated the phrase, "Genius knows no limits," which was transmitted to the distant end, and thence returned with all the success imaginable. The next phrase, "There are no longer miracles," was repeated with the same result, and many others followed, in which all the words were reproduced by the machines, letter for letter, with the greatest exactness.*

* The *English Chronicle* newspaper of June 19-22, 1802, has a short account of these experiments, concluding as follows:—"The art or mechanism by which this is effected is unknown, but the inventor says that he can extend it to the distance of four or five leagues, even though a river should be interposed."

(TO BE CONTINUED.)

VICTORIAN TELEGRAPHS.—According to the latest statistics to hand concerning the colony of Victoria, 135 miles of line were added to the telegraph system there during 1881, and 607 miles of wire. The number of telegrams which passed from Victoria to European and Asiatic countries and *vice versâ* during the same year was 12,168, the cost to the senders being £82,211. The average time occupied in the transmission of messages between Australia and England during 1881 is stated to have been three hours and 15 minutes.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

All communications to be addressed to 396, *Strand, London, W.C.*

We cannot undertake to return drawings or manuscripts, and must, therefore, request Correspondents to keep copies.

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ANSWERS TO CORRESPONDENTS.

C. TOWELL.—*You had better apply to the Duplex Electric Light Company, of Leicester-square, W.C., who are the makers of the batteries.*

PERPLEXED.—*We fear a short explanation will hardly help you. The result which perplexes you is a direct outcome of the fundamental laws of magnetism. If you read carefully the short chapters on magnetism now appearing in our columns you will, we have no doubt, be able to explain the phenomena. If, after reading these, you are still perplexed write again, and we will endeavour to make clear what now appears difficult.*

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PATENT LAW REFORM.

The very languid interest felt by the general public in the contemplated reform of the Patent Law is not difficult of explanation. So long as the public get what they want, it does not signify who makes the article or who sells it. This, at least, is probably what they would say if they were compelled to account for their indifference to a discussion which among persons immediately affected is carried on with much warmth and not a little acerbity. The fact is, according to popular estimate of the subject, we should get on just as well, and perhaps even better, without any patent laws at all. They are only tolerable on the grounds of long-established usage, and the practical difficulty of otherwise rewarding those who have done the nation some great service in making a valuable discovery or contriving some new and useful device. From the users' point of view, the claim of an inventor to be compensated adequately for the service he has rendered is the one justification of his obtaining a monopoly in the sale of his invention, that being, it is imagined, the only way in which he could be recompensed for his trouble. To the practical statesman the question presents itself in another form. He wishes not merely to pay the inventor, but to encourage invention, so that the country for whose interests he is specially responsible may have the benefit of the best that all the wit and industry of the nation can produce. He offers incentives and rewards for this kind of mental exercise in the form of a patent—the best means yet devised for inducing individuals to benefit their fellow men by their superior ingenuity.

This, roughly speaking, is how the matter stands between the public and those who represent it on the one hand, and the inventor on the other. It is not a particularly elevated view of man's duties and obligations, but it is supposed to be practical; and, at all events, it is the only view at all likely to prevail for some generations to come. Another view of it might be practicable, one that would secure to the owner what is his own and the reward he is entitled to, and to the user the right of using at a fair price what he is willing to pay for. But, unfortunately, nobody will take the trouble to discuss the Patent Laws in a philosophical spirit, partly for reasons already adverted to, but chiefly because nobody is so interested in them as the patent-mongers themselves, who, of course, are influenced by considerations not exclusively or even largely philosophical. They want the Patent Laws upheld because they can make money by them, and they want the existing laws reformed in order to make more money by them. The cry for reform from that quarter has been loud and long; just now the fashion for reforming everything is at its height, and the voice of the patentee has at length been heard.

We sincerely hope that the Bill now before Parliament will not disappoint the people whom it mainly concerns. It hardly concerns the general public at all, or, what amounts to the same thing, the general public could never be persuaded that it does concern them. The framers of the Bill have probably asked the patentee community what it really wanted, and having satisfied themselves that public interests would not be seriously affected by the proposed change, they have let the reformers have their own way. In some respects the law, or rather its interpretation, stands in need of emendation. Recent litigation has made this point only too manifest. There ought to be no sort of doubt as to what constitutes proprietorship, nor should there exist any technical weapons capable of depriving a man of rights that are undeniably his. Whether the measure now before Parliament will, if it become law, render these ever recurring scandals less frequent is another matter. If the examiners perform their duties efficiently in the initial stages of the patent, the after stages ought to be safe from litigation; but very much depends upon the sort of examiners chosen, and, in the opinion of some competent judges, their duties will very soon become either merely perfunctory, or else wholly vexatious.

Experience alone will decide the point just referred to; but in respect to the initial fees we can predict at once

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what the effect of reducing them will be. The number of patents will be immensely augmented. Some people are pleased to call this a stimulus to invention; we should prefer to call it a subsidy to patent agents. These worthy and painstaking go-betweens are as indispensable to the inventor as solicitors are to the litigant; but it is far from obvious that a large accession to their numbers will be an unmixed gain to the inventor, much less to the public. Inventors will no doubt also greatly multiply. Every petty aid to convenience will be dubbed an invention, as is the case already in America, and a vastly increased number of obscure persons will be anxious to purchase publicity at the small cost of a guinea. The sum total of inventiveness may not thereby be increased; on the contrary, it may even be diminished. But the figures will look big, and the agitators' mouths will be stopped. This is something, though not very much.

For our own part, we are inclined to think that if the securing of a patent is to be made so very easy and so very cheap, it might as well be made still easier and cheaper. Easier certainly it might be made. The fee is but a small fraction of the actual expense. There is the journey to London, which in a general way is desirable though not indispensable. Why not issue the provisional protection everywhere in the shape of a guinea stamp? Officially cancelled and dated on the spot, a document with such a stamp affixed would determine the question of date beyond all dispute, and if posted to the central office within so many hours, its registration and complete validity would be settled—so far, indeed, as the document is concerned. As to its validity as a *bonâ fide* patent, that would depend upon whether it were challenged. The probabilities of its being so challenged will increase with the number of patents issued—a very lively prospect for the lawyers, if not for the patentees and the public at large.

CORRESPONDENCE.

ELECTRICAL MACHINES AND THE TRANSMISSION OF POWER TO A DISTANCE.

(Translation.)

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The note addressed to the Academy of Sciences by M. Hospitalier on the influence exercised by the mode of connecting up dynamo-electric machines in the recent experiments on the transmission of power to a distance, reduces the result that can be attained in transmitting by means of two identical or similar machines to its just proportions. The importance of the question justifies the special mention of M. Hospitalier's communication made in *The Electrician* of March 24. As a sequel to this note I should like to record certain points which result from researches and experiments that I have recently made. You will, perhaps, find that my notes are worthy of attention; and, if so, I beg you will be good enough to publish this letter in your paper.

The complete solution of the problem of the transmission of power by means of electricity does not seem to me to be possible *under actual working conditions*; that is to say, effective work cannot be transmitted by this means with economic and favourable results so long as identical or similar machines are used as generator and receiver.

Most likely it will be necessary to design two very distinct classes of machines—one to be used as generators solely, the others principally as receivers (or motors). When it is required to transmit power to a distance, it will be necessary for the receiver to be of large dimensions as compared with the generator, and possibly it will be found markedly advantageous to build the generators without cores (*sans noyeaux*) and the receivers without wire! This latter arrangement would allow of the reduction of the counter electromotive force, which is at present produced by the second machine. Considerable progress would evidently be made by the suppression or diminution of this counter effect, which results from the fact that the two machines throw into circuit two contrary currents, which nullify each other. But could we hope to realise such a result?

It would be premature to state that this result could be practically and completely attained; but we believe that the solution of the problem of transmitting power by means of electricity for every day uses must be looked for in a modification of the machines to suit the circumstances. This opinion is based on the most striking of the mechanical analogies of electricity. For instance, the phenomena attending the electrical transmission of power are absolutely similar to those observed when two centrifugal ventilating fans are in action, the one being actuated by some motor, and the other receiving its motion from the air emitted by the first, the two being connected by a conducting pipe along which the air is transmitted. The inherent weakness of such a system is seen at once. The fans acting by the centrifugal force developed, and emptying themselves into the same pipe, a large portion of the energy of the motive current of air is uselessly expended in overcoming the inverse current generated by the receiving fan.

Now, the same effects take place in a circuit with two similar dynamo machines. These tend to throw into it contrary currents, having a nullifying effect on each other, and consequently the resultant power is merely the difference between these two actions.

In the pneumatic system we can partly remedy this loss by absorption of a part of the power generated. For, by erecting a fan with a close fitting case, it is always possible to transform the dynamic potential of any sector into static potential. This transformation is necessarily effected by detention. The current of air which is carried from the centre towards the circumference is inflected, and takes an opposite direction. Thus, when any obstacle compels the dynamic centifrugal action to alter its potential this change in the equilibrium of bodies of air in movement must necessarily produce a dynamical reaction. It is sufficient, therefore, so to arrange matters that the motive air current emitted by the first fan shall arrive at the paddles of the second at the exact moment when the transformation of the dynamical action is taking place there. Now, the pressure in the pipe will not meet with counter pressures to partly neutralise it, and its action can be more effectively utilised. To obtain this result, it is only necessary to increase the diameter of the second fan as compared with the first, and to furnish the receiver with a second way of escape for the centrifugal current generated by it. In this way the counter pressure in the sector which is about to receive the motive current will be lowered, and the effective power obtained will be increased.

The analogy between the electrical phenomena developed in a system for transmitting power to a distance by means of electricity, and those which are developed in a pneumatic system, comprising two fans and a pipe to connect them, is so complete that we believe that electrical machines must be modified in an analogous way to the fans if we are to have a satisfactory return from electricity.

Evidently the two dynamos should not be similar. The receiving machine might be usefully furnished with shunt circuits or condensers properly placed, so as to prevent the generation of counter electromotive force in the circuit which connected the two machines.

We condense steam when it has given up its useful work; and are not our most powerful engines worked on this system? The question awaits solution, and I think I have done enough in calling the attention of those interested in the matter to the direction in which researches should be prosecuted.—Yours, &c.,

(Signed) A. BANDSEPT, N.F.

Chaussée de Wavre 15, Bruxelles.

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TELEPHONY.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your readers furnish statistics as to the various methods and approximate proportions of each of the arrangements used in this country for giving the call signals in connection with telephony? To me the ordinary electric bell and battery with push (used in combination with a switch) seems to be by far the most general arrangement; but surely this is a very expensive and troublesome plan as compared with the magneto-electric generators introduced some time since, and which I may say are universally used in America. These do not depend upon any battery (chemical) for their action, nor has the bell any contact points to get out of order, and from what I have seen of them I think they will keep in order better, give less trouble, and consequently cost less to maintain than the electro-magnetic or "battery" bells. Perhaps there are objections to the introduction of these magneto generators and bells in this country, which objections do not exist in America; if so, I should like to have them pointed out, as it seems so strange that inferior methods should remain in vogue when better are at hand.

These magneto machines are (like the "battery" bells) made up in a combination form, with a switch to operate the telephone and microphone circuits, and, like other things, exist in many forms, some of which are considered better than others. Doubtless a few of your readers are acquainted with and have had experience with various makes of instruments. If so, could they be induced to report their experience as to what they consider the best of these arrangements, and give a comparison between home and American-made apparatus? I do not refer so much to work-bench tests, such as resistances of armatures and bell coils, lifting power of magnets, &c., as I do to the experience noted from the actual running and lasting qualities of the bells. At present there does not seem to be any necessity for powerful generators in this country, *i.e.*, if a magneto will ring well through 100 miles of ordinary line, say 2,500^{m}, it is ample for present and all probable future requirements.—Yours, &c.,

U. Q.

REIS'S TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have just received yours of the 6th. I am sorry I cannot give you any information other than that published in the *Journal of Telegraph Engineers*. I have had very little practical experience with it since I first brought it over beyond making about eight or ten of them. I never attempted articulation, but I easily got a distinction of notes in singing.—Yours, &c.,

W. LADD.

Claremont Villa, Rectory-road, Beckenham,
April 14, 1883.

[Thinking that Mr. Ladd might be able to contribute still further to the history of Reis's telephone, we asked if he could favour us with any other information on the subject. The above is the reply we received from him.—ED. *E.*]

TESTING LIGHTNING CONDUCTORS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: From *The Electrician's* account of the testing of the old and new lightning conductors on the General Assembly Hall, Edinburgh, the question arises what should be considered a safe margin to allow when testing a conductor, whether 10, 20, or even 30 ohms? I recently tested one newly erected, and found it to give $\frac{1}{20}$th ohm for metallic circuit, but 95 when to earth. How is that for good?—Yours, &c.,

GOOD EARTH.

HOW IT CAN BE DONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: There is one great convenience about the house-to-house supply which has been overlooked. If earth is not used as the return, nothing is easier than to make arrangements with a suitable friend at another part of the circuit to put one side of our respective low resistance lamps or motors to earth, *viâ* water pipe, instead of to the wire in which the meter happens to be, thus saving much wear and tear of the said meters.—Yours, &c.,

JER. DIDDLER.

CONNECTING CONDUCTORS.

The address of the writer of the letter which appeared under this head in our last issue, p. 519, was accidentally omitted. It should have been W. Bridges Adams, Manager, Electric Lighting Supply and Fitting Company, 28, York-street, Westminster, S.W.

THE INSTITUTION OF CIVIL ENGINEERS.

The fourth of the series of six lectures on the Applications of Electricity was delivered on Thursday evening, the 5th of April, by Dr. John Hopkinson, F.R.S., M. Inst. C.E. The subject was "Some Points in Electric Lighting." The following is an abstract of the lecture:—

The science of lighting by electricity was divided by the lecturer into two principal parts—the methods of production of electric currents, and of conversion of the energy of those currents into heat at such a temperature as to be given off in radiations to which the eye was sensible. The laws known to connect together those phenomena called electrical were essentially mechanical in form, closely correlated with mechanical laws, and might be most aptly illustrated by mechanical analogues. For example, the terms "potential," "current," and "resistance," had close analogues respectively in "head," "rate of flow," and "co-efficient of friction" in the hydraulic transmission of power. Exactly as in hydraulics head multiplied by velocity of flow was power measured in foot-pounds per second or in horse-power, so potential multiplied by current was power and was measurable in the same units. Again, just as water flowing in a pipe had inertia and required an expenditure of work to set it in motion, and was capable of producing disruptive effects if that motion were too suddenly arrested, so a current of electricity in a wire had inertia; to set it moving electromotive force must work for a finite time, and if arrested suddenly by breaking the circuit the electricity forced its way across the interval as a spark. Corresponding to mass and moments of inertia in mechanics there existed in electricity co-efficients of self-induction. There was, however, this difference between the inertia of water in a pipe and the inertia of an electric current—the inertia of the water was confined to the water, whereas the inertia of the electric current resided in the surrounding medium. Hence arose the phenomena of induction of currents upon currents, and of magnets upon moving conductors—phenomena which had no immediate analogues in hydraulics.

The laws of induction were then illustrated by means of a mechanical model devised by the late Professor Clerk Maxwell.

In the widest sense, the dynamo-electric machine might be defined as an apparatus for converting mechanical energy into the energy of an electrostatic charge, or mechanical power into its equivalent electric current through a conductor. Under this definition would be included the electrophorus and all frictional machines; but the term was used in a more restricted sense, for those machines which produced electric currents by the motion of conductors in a magnetic field, or by the motion of a magnetic field in the neighbourhood of a conductor. The laws on which the action of such machines was based had been the subject of a series of discoveries. Oersted discovered that an electric current in a conductor exerted force upon a magnet; Ampère that two conductors conveying currents generally exerted a mechanical force upon each other; Faraday discovered—what Helmholtz and Thomson subsequently proved to be the necessary consequence of the mechanical reactions between conductors conveying currents and magnets—namely, that if a closed conductor moved in a magnetic field, there would be a current induced in that conductor in one direction, if the number of lines of magnetic force passed through the conductor was increased by the movement, in the other direction if diminished. Now all dynamo-electric machines were based upon Faraday's discovery. Not only so; but however elaborate it might be desired to make the analysis of the action of a dynamo-machine, Faraday's way of presenting the phenomena of electro-magnetism to the mind was in general the best point of departure. The dynamo-machine, then, essentially consisted of a conductor made

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to move in a magnetic field. This conductor, with the external circuit, formed a closed circuit in which electric currents were induced as the number of lines of magnetic force passing through the closed circuit varied. Since, then, if the current in a closed circuit was in one direction when the number of lines of force was increasing, and in the opposite direction when they were diminishing, it was clear that the current in each part of such circuit which passed through the magnetic field must be alternating in direction, unless indeed the circuit was such that it was continually cutting more and more lines of force, always in the same direction. Since the current in the wire of the machine was alternating, so also must be the current outside the machine, unless something in the nature of a commutator was employed to reverse the connections of the internal wires in which the current was induced, and of the external circuit. There were, then, broadly two classes of dynamo-electric machines; the simplest, the alternating-current machine, where no commutator was used; and the continuous-current machine, in which a commutator was used to change the connection with the external circuit just at the moment when the direction of the current would change. The theory of the alternate-current machine was then explained, and it was proved that two independently driven alternate-current machines could not be worked in series, but that they might be worked in parallel circuit, and hence were quite suitable for distribution of electricity for lighting without the necessity of providing a separate circuit for each machine.

It was easy to see that, by introducing a commutator revolving with the armature in an alternate-current machine, and so arranged as to reverse the connection between the armature and the external circuit just at the time when the current would reverse, it was possible to obtain a current constant always in direction; but such a current would be far from constant in intensity, and would certainly not accomplish all the results obtained in modern continuous-current machines. This irregularity might, however, be reduced to any extent by multiplying the wires of the armature, giving each its own connection to the outer circuit, and so placing them that the electromotive force attained a maximum successively in the several coils. A practically uniform electric current was first commercially produced with the ring armature of Pacinotti, as perfected by Gramme. A dynamo-machine was not a perfect instrument for converting mechanical energy into the energy of electric current. Certain losses inevitably occurred. There was the loss due to friction of bearings, and of the collecting-brushes upon the commutator; there was also the loss due to the production of electric currents in the iron of the machine. When these were accounted for, there remained the actual electrical effect of the machine in the conducting wire; but all of this was not available for external work. The current had to circulate through the armature, which inevitably had electrical resistance; electrical energy must, therefore, be converted into heat in the armature of the machine. Energy must also be expended in the wire of the electro-magnet which produced the field, as the resistance of this also could not be reduced beyond a certain limit. The loss by the resistance of the wires of the armature and of the magnets greatly depended on the dimensions of the machine. To know the properties of any machine thoroughly, it was not enough to know its efficiency and the amount of work it was capable of doing; it was necessary to know what it would do under all circumstances of varying resistance or varying electromotive force; and, under any given conditions, what would be the electromotive force of the armature? Now this electromotive force depended on the intensity of the magnetic field, and the intensity of the magnetic field depended on the current passing round the electro-magnet and the current in the armature. The current then in the machine was the proper independent variable in terms of which to express the electromotive force. The simplest case was that of the series-dynamo, in which the current in the electro-magnet and in the armature was the same, for then there was only one independent variable. The relation between electromotive force and current might be most conveniently expressed by a curve.

When, four years ago, the lecturer first used such a curve (since named by Deprez the "characteristic curve") for the purpose of expressing the results of his experiments on the Siemens dynamo-machine, he pointed out that it was capable of solving almost any problem relating to a particular machine, and that it was also capable of giving good indications of the results of changes in the winding of the magnets, or of the armatures of such machines. The use of the characteristic curve was illustrated with reference to charging accumulators and Jacobi's law of electric transmission of power.

When the dynamo-machine was not a series-dynamo, but the current in the armature and in the electro-magnet, though possibly dependent upon each other, were not necessarily equal, the problem was not so simple. In that case there were two variables, the current in the electro-magnet and the current in the armature; and the proper representation of the properties of the machine would be by a characteristic surface, of which a model was exhibited. By the aid of such a surface any problem relating to a dynamo-machine could be dealt with, no matter how its electro-magnets and its armature were connected together. Of course, in actual practice the model of the surface would not be used, but the projections of its sections.

The properties of a machine depended much upon its dimensions. Suppose two machines alike in every particular, excepting that the one had all its linear dimensions double that of the other. The electrical resistances in the larger machine would be one-half those of the smaller. The current required to produce a given intensity of magnetic field would be twice as great in the larger machine as in the smaller. The comparative characteristic curves of the two machines, when driven at the same speed, were shown in a diagram. The two curves were one the projection of the other, having corresponding points with abscisses in the ratio of one to two, and the ordinates in the ratio of one to four. At first sight it would seem that the work done by the larger machine should be thirty-two times as much as that which would be done by the smaller. Practically, however, no such result could possibly be attained, for many reasons. First, the iron of the magnets became saturated, and consequently, instead of eight times the electromotive force, there would only be four times the electromotive force. Secondly, the current which the armature could carry was limited by the rate at which the heat generated in the armature could escape. Again, the larger machine could not run at so great an angular velocity as the smaller one. And lastly, since in the larger machine the current in the armature was greater in proportion to the saturated magnetic field than in the smaller one, the displacement of the point of contact of the brushes with the commutator would be greater. Shortly, the capacity of similar dynamo-machines was pretty nearly proportionate to their weight, that was to the cube of their linear dimensions. The work wasted in producing the magnetic field was directly as the linear dimensions; and the work wasted in heating the wires of the armature was as the square of the linear dimensions.

A consideration of the properties of similar machines had another important practical use. Mr. Froude was able to control the design of ironclad ships by experiments upon models made in paraffin wax. It was a much easier thing to predict what the performance of a large dynamo machine would be from laboratory experiments made upon a model of a very small fraction of its dimensions. As a proof of the practical utility of such methods, the lecturer stated that by laboratory experiments he had succeeded in greatly increasing the capacity of the Edison machines, without increasing their cost, and with a small increase of their percentage of efficiency, remarkably high as that efficiency already was.

The electric properties of the electric arc were experimentally illustrated; in particular it was shown that the difference of potential between the carbons was nearly independent of the current.

When a current of electricity passed through a continuous conductor, it encountered resistance, and heat was generated, as shown by Joule, at a rate represented by the resistance multiplied by the square of the current. If the current was sufficiently great, heat would be generated at such a rate that the conductor would become incandescent and radiate light. Attempts had been made to use platinum and platinum iridium as the incandescent conductor. But these bodies were too expensive for general use, and besides that, refractory though they were, they were not refractory enough to stand the high temperature required for incandescent lighting, which should be economical of power. Commercial success was not realised until very thin and very uniform threads or filaments of carbon were produced and enclosed in reservoirs of glass, from which the air was exhausted to the utmost possible limit. Such were the lamps made by Mr. Edison, with which the Institution was temporarily lighted. The electrical properties of such a lamp were examined, and in particular it was shown that its efficiency increased and its resistance diminished with increase of current.

The building was lighted by about 230 lamps, each giving sixteen candles light, produced each by seventy-five watts of power developed in the lamp. To produce the same sixteen candles light in ordinary good flat-flame gas-burners, would require between seven and eight cubic feet of gas per hour, contributing heat to the atmoshere at the rate of 3,400,000 ft.-lbs. per hour, equivalent to 1,250 watts, or nearly seventeen times as much heat as the incandescence lamp of equal power.

At the present time, lighting by electricity in London must cost something more than lighting by gas. What were the prospects of reduction of this cost? Beginning with the engine and boiler, the electrician had no right to look forward to any marked and exceptional advance in their economy. Next came

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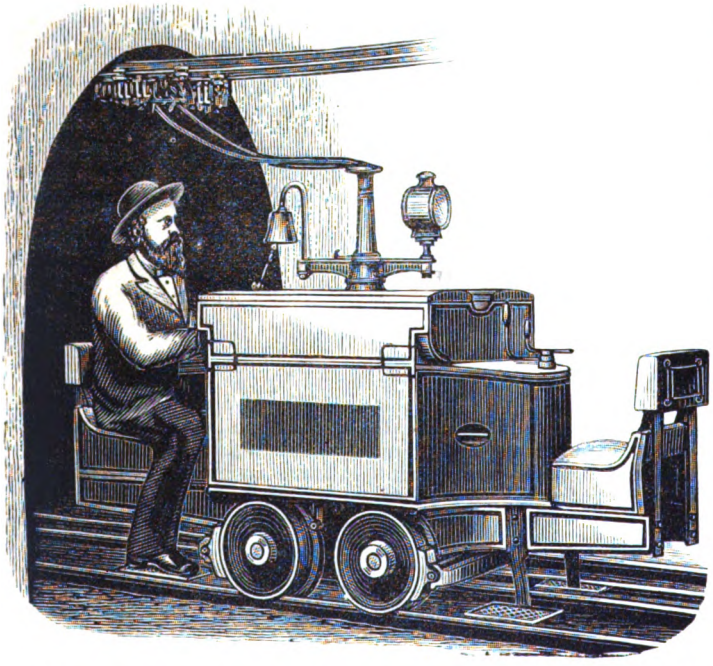
the dynamo. The best of these were so good that there was little room for economy in the conversion of mechanical into electrical energy; but the prime cost of the dynamo-machine was sure to be greatly reduced. Hope of considerably increased economy must be mainly based upon probable improvements in the incandescence lamp, and to this the greateast attention ought to be directed. It had been shown that marked economy of power could be obtained by working the lamps at high pressure, but then they soon broke down. In ordinary practice, from 140 to 200 candles were obtained from 1 horse-power developed in the lamps, but for a short time he had seen over 1,000 candles per horse-power from incandescence lamps. The problem, then, was so to improve the lamp in details, that it would last a reasonable time when pressed to that degree of efficiency. There was no theoretical bar to such improvements, and it must be remembered that incandescence lamps had only been articles of commerce for about three years, and already much had been done. If such an improvement were realised, it would mean that it would be possible to get five times as much light for a sovereign as could be done now. At present electric lighting would succeed commercially where other considerations than cost had weight. Improvements in the lamps were certain, and there was a probability that these improvements might go so far as to reduce the cost to one-fifth of what it now was. He left the meeting to judge whether or not it was probable, nay, almost certain, that lighting by electricity was to be the lighting of the future.

I. THE TRANSMISSION OF POWER BY ELECTRICITY.*
II. THE PORTRUSH ELECTRICAL RAILWAY.

BY ALEXANDER SIEMENS AND EDWARD HOPKINSON, D.SC.

(CONCLUDED FROM PAGE 524.)

Now let us put these considerations in a mathematical form. The first problem is :—Given a main with a constant E.M.F. de-



View of engine employed at the mines at Zankerode, in Saxony, an illustration of which was shown at the meeting by Mr. Siemens (*see* p. 523 of our last issue). The dynamo is placed with its axis lengthwise on the car, and works one pair of driving wheels by means of bevel gear. The current is conveyed along the roof of the workings by means of an inverted tee iron rail, on which a contact carriage freely slides, and connects with the engine by a flexible cable carried down the tube. The return current is taken by a similar cable and carriage to a second conductor, fixed by the side of the first.

noted by E, to construct a dynamo machine, drawing its current from the main, to work with a given load, L, and at a given number of revolutions, n, per minute. Let us make use of the characteristic curves, used by Dr. J. Hopkinson, Dr. Frölich, M. Marcel Deprez, and others.

Take Ox, Oy (Fig. 1) as axes of co-ordinates, along Oy, cut off

* Paper read before the Society of Arts on Wednesday, April 11, 1883.

O M, representing the E.M.F. of the main in volts. Now makers of each type of dynamo machine know approximately the percentage of energy their machines absorb in producing the necessary magnetic field. Take a point, N, in O M, such that the ratio $\frac{O\,N}{O\,M}$ is equal to this percentage. Again, it is known that a dynamo is not an absolutely perfect machine, but that a certain amount of energy is wasted in the friction of the bearings, and of the brushes against the commutator, and also in induced currents in the core of the armature. Take O R, such that $\frac{O\,R}{O\,N}$ represents the efficiency of the machine. This, in the case of the Siemens

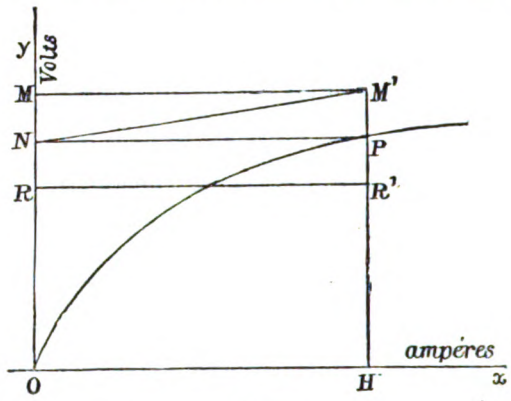


Fig. 1.

machine, is at least 90 per cent. From Ox cut off O H, such that the rectangle O H R′ R represents the power required from the motor expressed in watts. Then O H is the current passing through the motor, measured in amperes, and H P is the inverse E.M.F. The proper motor, therefore, is that dynamo which, when running at the given number of revolutions n per minute, has a characteristic curve passing through the point P. The total efficiency is evidently the ratio of the rectangle O H R′ R to the rectangles O H M′ M, which is equal to $\frac{H\,R'}{H\,M'}$; the electrical efficiency is $\frac{H\,P}{H\,M'} = \frac{E'}{E}$, the ratio of the inverse E.M.F. of the motor to the E.M.F. of the main. The energy spent in magnetisation is measured by P N M M′, and the tangent of the angle P N M′ represents the resistance of the armature and magnets.

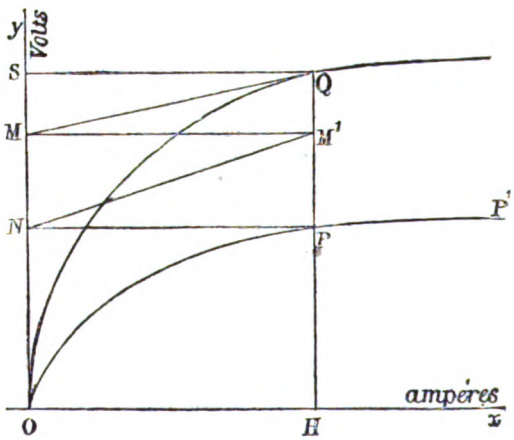


Fig. 2.

The second problem is :—Given a motor requiring a certain current and E.M.F. for the work it has to do, to construct a suitable generator, the distance between the machines being represented by an electrical resistance R measured in ohms. Let O P P′ (Fig. 2) be the characteristic curve of the motor, when running at the required speed; P H the E.M.F. in volts, and Q H the current in amperes. Let R′ be the sum of the resistances of the motors, and R conductor. Draw P N perpendicular to Oy, and make the angle P N M′, having its tangent equal to R′; then M′ H represents the difference of potential between the terminals of the generator. Produce H M′ to Q, so that $\frac{Q\,M'}{Q\,H}$ is the ratio of the energy expended in producing the magnetic field to the total energy of the machine; then the

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generator is that dynamo which, when running at its proper speed, has a characteristic curve passing through the point Q.

The electrical efficiency of the combination is the ratio $\frac{PH}{QH'}$, *i.e.*, the ratio of the E.M.F. of the motor to the E.M.F. of the generator, which, if the machines are similar, is equal to the ratio of their speeds. The energy converted into heat in the wires of the machine, and in the conductor, is NPQS; and the total efficiency of the combination is the ratio of the electromotive forces, multiplied by the product of the efficiencies of the two machines, considered separately. The conductor connecting the two machines has been considered to be perfectly insulated. Of course, this is not practically attained, but I will not now consider the point particularly, as it is has very recently been discussed from an analytical point of view by Dr. O. J. Lodge.

The diagrams might be used for proving many other points of interest in connection with the theory of transmission of power, especially Jacobi's law of maximum effect; but I think it will probably be of more advantage to leave the rest of the time at our disposal to Dr. Edward Hopkinson, to describe the Portrush Railway, the electrical part of the work of which he has had in charge, under the direction of Dr. Siemens, particularly as it will illustrate how these principles have been carried out in practice, and the results obtained therefrom.

II. The Portrush Railway.

In the summer of 1881, Mr. W. A. Traill, late of H.M. Geological Survey, suggested to Dr. Siemens that the line between Portrush and Bushmills, for which parliamentary powers had been obtained, would be suitable in many respects for electrical working, especially as there was abundant water-power available in the neighbourhood. Dr. Siemens at once joined in the undertaking, which has been carried out under his direction. The line extends from Portrush, the terminus of the Belfast and Northern Counties Railway, to Bushmills in the Bush Valley, a distance of six miles. For about half a mile the line passes down the principal street of Portrush, and has an extension along the Northern Counties Railway to the harbour. For the rest of the distance, the rails are laid on the seaside of the county road, and the head of the rails being level with the ground, a footpath is formed the whole distance, separated from the road by a kerb-stone. The line is single, and has a gauge of three feet, the standard of the existing narrow gauge lines in Ulster. The gradients are exceedingly heavy, as will be seen from the diagram, being in parts as steep as 1 in 35. The curves are also in many cases very sharp, having necessarily to follow the existing road. There are five passing places in addition to the sidings at the termini and at the carriage depôt. At the Bushmills end the line is laid for about 200 yards along the street, and ends in the market-place of the town. It is intended to connect it with an electrical railway from Dervock, for which parliamentary powers have already been obtained, thus completing the connection with the narrow gauge system from Ballymena to Larne and Cushendall. About 1,500 yards from the end of the line there is a waterfall on the River Bush, with an available head of 24ft., and an abundant supply of water at all seasons of the year. Turbines are now being erected, and the necessary works executed for employing the fall for working the generating dynamo machines, and the current will be conveyed by means of an underground cable to the end of the line. Of the application of the water-power it is unnecessary to speak further, as the works are not yet completed. For the present the line is worked by a small steam engine placed at the carriage depôt at the Portrush end. The whole of the constructive works have been designed and carried out by Mr. Traill, assisted by Mr. E. B. Price.

The system employed may be described as that of the separate conductor. A rail of tee-iron, weighing 19lbs. to the yard, is carried on wooden posts, boiled in pitch, and placed 10 feet apart, at a distance of 22 inches from the inside rail and 17 inches above the ground. This rail comes close up against the fence on the side of the road, thus forming an additional protection. The conductor is connected by an underground cable, to a single shunt-wound dynamo machine, placed in the engine shed, and worked by a small agricultural steam-engine of about 25 indicated horse-power. The current is conveyed from the conductor by means of two springs, made of steel, rigidly held by two steel bars placed one at each end of the car, and projecting about six inches from the side. Since the conducting rail is iron, while the brushes are steel, the wear of the latter is exceedingly small. In dry weather they require the rail to be slightly lubricated; in wet weather the water on the surface of the iron provides all the lubrication required. The double brushes, placed at the extremities of the car, enable it to bridge over the numerous gaps, which necessarily interrupt the conductor to allow cart ways into the fields and commons adjoining the shore. On the diagram the car is shown passing one of these gaps; the front brush has broken contact, but since the back brush is still touching the rail the current has not been broken. Before the back brush leaves the conductor the front brush will have again risen upon it, so that the current is never interrupted. There are two or three gaps too broad to be bridged in this way. In these cases the driver will break the current before reaching the gap, the momentum of the car carrying it the 10 or 12 yards it must travel without power.

The current is conveyed under the gaps by means of an insulated copper cable carried in wrought-iron pipes placed at a depth of 18 inches. At the passing places, which are situated on inclines, the conductor takes the inside, and the car ascending the hill also runs on the inside, while the car descending the hill proceeds by gravity on the outside lines.

From the brushes the current is taken to a commutator worked by a lever, which switches resistance-frames placed under the car, in or out, as may be desired. The same lever alters the position of the brushes on the commutator of the dynamo machine, reversing the direction of rotation, in the manner shown by the electrical hoist. The current is not, as it were, turned full on suddenly, but passes through the resistances, which are afterwards cut out in part or altogether, according as the driver desires to run at part speed or full speed.

From the dynamo, the current is conveyed through the axle-boxes to the axles, thence to the tyres of the wheels, and finally back by the rails, which are uninsulated, to the generating machine. The conductor is laid in lengths of about 21ft., the lengths being connected by fish plates and also by a double copper loop securely soldered to the iron. It is also necessary that the rails of the permanent way should be connected in a similar manner, as the ordinary fish-plates give a very uncertain electrical contact, and the earth for large currents is altogether untrustworthy as a conductor, though no doubt materially reducing the total resistance of the circuit.

The dynamo is placed in the centre of the car, beneath the floor, and through intermediate spur gear drives by a steel chain on to one axle only. The reversing levers, and also the levers working the mechanical brakes, are connected to both ends of the car, so that the driver can always stand at the front and have uninterrupted view of the rails, which is, of course, essential in the case of a line laid by the side of the public road.

The cars are first and third class, some open and some covered, and are constructed to hold twenty people, exclusive of the driver. At present, only one is fitted with a dynamo, but four more machines are now being constructed by Messrs. Siemens Brothers, so that before the beginning of the heavy summer traffic five cars will be ready; and since two of these will be fitted with machines capable of drawing a second car, there will be an available rolling stock of seven cars. It is not intended at present to work electrically the portion of the line in the town at Portrush, though this will probably be done hereafter; and a portion, at least, of the mineral traffic will be left for the two steam tramway engines, which were obtained for the temporary working of the line pending the completion of the electrical arrangements.

Let us now put in a form suitable for calculation, the principles which Mr. Siemens has illustrated in a graphic form more convenient for the purposes of explanation, and then show how these principles have been applied in the present case.

Let L be the couple, measured in foot-pounds, which the dynamo must exert in order to drive the car, and w the necessary angular velocity. Taking the tare of the car as 50 cwt., including the weight of the machinery it carries, and a load of twenty people as 30 cwt., we have a gross weight of 4 tons. Assume that the maximum required is that the car should carry this load at a speed of seven miles an hour, on an incline of 1 in 40. The resistance due to gravity may be taken as 56lb. per ton, and the frictional resistance, and that due to other causes, say 14lb. per ton, giving a total resistance of 280lb., at a radius of 14in. The angular velocity of the axle corresponding to a speed of seven miles an hour is 84 revolutions per minute. Hence L = 327 foot-pounds, and $w = \frac{2\pi \times 84}{60}$.

If the dynamo be wound directly on the axle, it must be designed to exert the couple L, corresponding to the maximum load, when revolving at an angular velocity w, the difference of potential between the terminals being the available E.M.F. of the conductor, and the current the maximum the armature will safely stand. This will be the case in the Charing-cross Electrical Railway. But when the dynamo is connected by intermediate gear to the driving wheels only the product of L and w remains constant, and the two factors may be varied. In the present case L is diminished in the ratio of 7 to 1, and w conse-

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quently increased in the same ratio. Hence the dynamo, with its maximum load, must revolve at 588 revolutions per minute, and exert a couple of 47 foot-pounds. Let E be the potential of the conductor from which the current is drawn, measured in volts, C the current in amperes, and E_1 the E.M.F. of the dynamo. Then E_1 is proportional to the product of the angular velocity, and a certain function of the current. For a velocity, ω, let this function be denoted by $f(C)$. If the characteristic of the dynamo can be drawn, then $f(C)$ is known.

We have then

$$E_1 = \frac{w}{\Omega} f(C). \quad . \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

If R be the resistance in circuit, by Ohm's law,

$$C = \frac{E - E_1}{R} = \frac{E - \frac{w}{\Omega} f(C)}{R}$$

And, therefore,

$$w = \frac{\Omega (E - C R)}{f(C)}. \quad . \quad . \quad . \quad . \quad . \quad (2.)$$

Let a be the efficiency with which the motor transforms electrical into mechanical energy, then—

$$\text{Power required} = L w = a E_1 C, = a C \frac{w}{\Omega} f(C).$$

Dividing by w,

$$L = \frac{a C f(C)}{\Omega}. \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

It must be noted that L is here measured in electrical measure, or adopting the unit given by Dr. Siemens in the British Association address in joules. One joule equals approximately ·74 foot-pounds. Equation (3) gives at once an analytical proof of the second principle stated above, and that for a given motor the current depends upon the couple, and upon it alone. Equation (2) shows that with a given load the speed depends upon E, the electromotive force of the main, and R the resistance in circuit. It shows also the effect of putting into the circuit the resistance frames placed beneath the car. If R be increased until C R is equal to E, then w vanishes, and the car remains at rest. If R be still further increased, Ohm's law applies, and the current diminishes. Hence, suitable resistances are—first, a high resistance for diminishing the current, and, consequently, the sparking at making and breaking of the circuit; and, secondly, one or more low resistances for varying the speed of the car. If the form of $f(C)$ be known, as is the case with a Siemens machine, Equations (2) and (3) can be completely solved for w and C, giving the current and speed in terms of L E and R. The expressions so obtained are not without interest, and agree with the results of experiment.

It may be observed that an arc light presents the converse case to a motor. The E.M.F. of the arc is approximately constant, whatever the intensity of the current passing between the carbons; and the current depends entirely on the resistance in circuit. Hence the instability of an arc produced by machines of low internal resistance, unless compensated by considerable resistance in the leads.

The following experiment shows in a striking form the principles just considered. An Edison lamp is placed in parallel circuit with a small dynamo machine used as a motor. The Prony brake on the pulley of the dynamo is quite slack, allowing it to revolve freely. Now let the lamp and dynamo be coupled to the generator running at full speed. First, the lamp glows, in a moment it again becomes dark, then, as the dynamo gets up speed, glows again. If the brake be screwed up tight the lamp once more becomes dark. The explanation is simple. Owing to the co-efficient of self-induction of the dynamo machine being considerable, it takes a finite time for the current to obtain an appreciable intensity, but the lamp having no self-induction, the current at once passes through it, and causes it to glow. Secondly, the electrical inertia of the dynamo being overcome, it must draw a large current to produce the kinetic energy of rotation, *i.e.*, to overcome its mechanical inertia; the lamp is therefore practically short-circuited, and ceases to flow. When once the rotation has been established, the current through the dynamo becomes very small, having no work to do except to overcome the friction of the bearings, hence the lamp again glows. Finally, by screwing up the brake, the current through the dynamo is increased, and the lamp again short-circuited.

It has often been pointed out that reversal of the motor on the car would be a most effective brake. This is certainly true; but, at the same time, it is a brake that should not be used except in cases of emergency. For this reason, the dynamo revolving at a high speed the momentum of the current is very considerable; hence, owing to the self-induction of the machine, a sudden reversal will tend to break down the insulation at any weak point of the machine. The action is analogous to the spark produced by a Ruhmkorff coil. This was illustrated at Portrush. When the car was running perhaps fifteen miles an hour the current was suddenly reversed. The car came to a standstill in little more than its own length, but at the expense of breaking down the insulation of one of the wires of the magnet coils. The way out of the difficulty is evidently at the moment of reversal to insert a high resistance to diminish the momentum of the current.

In determining the proper dimensions of a conductor for railway purposes Sir William Thomson's law should properly apply, but on a line where the gradients and traffic are very irregular it is difficult to estimate the average current; and the desirability of having the rail mechanically strong, and of such low resistance that the potential shall not vary very materially throughout its length, becomes more important than the economic considerations involved in Sir William Thomson's law. At Portrush the resistance of a mile, including the return by earth and the ground rails is actually about 0·23 ohm. If calculated from the section of the iron it would be 0·15 ohm, the difference being accounted for by the resistance of the copper loops, and occasional imperfect contacts. The E.M.F. at which the conductor is maintained is about 225 volts, which is well within the limit of perfect safety assigned by Sir William Thomson and Dr. Siemens. At the same time the shock received by touching the iron is sufficient to be unpleasant, and hence is some protection against the conductor being tampered with.

Consider a car requiring a given constant current; evidently the maximum loss due to resistance will occur when the car is at the middle point of the line, and will then be one-fourth of the total resistance of the line, provided the two extremities are maintained by the generators at the same potential. Again, by integration, the mean resistance can be shown to be one-sixth of the resistance of the line. Applying these figures, and assuming four cars are running, requiring 4 horse-power each, the loss due to resistance does not exceed 4 per cent. of the power developed on the cars; or if one car only be running, the loss is less than 1 per cent. But in actual practice at Portrush even these estimates are too high, as the generators are placed at the bottom of the hills, and the middle portion of the line is more or less level, hence the minimum current is required when the resistance is at its maximum value.

The insulation of the conductor has been a matter of considerable difficulty, chiefly on account of the moistness of the climate. An insulation has now, however, been obtained of from 500 to 1,000 ohms per mile, according to the weather, by placing a cap of insulite between the wooden posts and tee-iron (see Fig. 3).

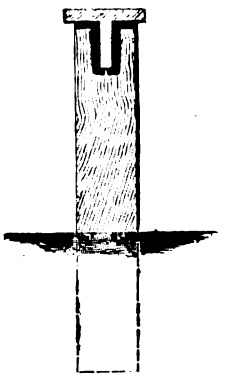

Fig. 3.

Hence the total leakage cannot exceed 2·5 amperes, representing a loss of three-fourths of a horse-power, or under 5 per cent., when four cars are running. But, apart from these figures, we have materials for an actual comparison of the cost of working the line by electricity and steam. The steam tramway engines temporarily employed at Portrush are made by Messrs. Wilkinson, of Wigan, and are generally considered as satisfactory as any of the various tramway engines. They have a pair of vertical cylinders 8in. diameter, and 1ft. stroke, and work at a boiler pressure of 120lb., the total weight of the engine being 7 tons. The electrical car with which the comparison is made has a dynamo weighing 13 cwt., and the tare of the car is 52 cwt. The steam engines are capable of drawing a total load of about 12 tons up the hill, excluding the weight of the engine; the dynamo over 6 tons, excluding its own weight; hence, weight for weight, the dynamo will draw five times as much as the steam engine. Finally, compare the following estimates of cost. From actual

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experience, the steam engine, taking an average over a week, costs:—

	£	s.	d.
Driver's wages	1	10	0
Cleaner's ditto	0	12	0
Coke, 58½ cwt., at 25s. per ton	3	13	1½
Oil, 1 gallon, at 3s. 1d.	0	3	1
Tallow, 4lb., at 6d.	0	2	0
Waste, 8lb., at 2d.	0	1	4
Depreciation, 15 per cent. on £750	2	3	3
Total	£8	4	9½

The distance run was 312 miles. Also, from actual experience, the electrical car, drawing a second behind it, and hence providing for the same number of passengers, consumed 18lb. of coke per mile run. Hence, calculating the cost in the same way, for a distance run of 312 miles in a week—

	£	s.	d.
Wages of stoker of stationary engine	1	0	0
Coke, 52 cwt., at 25s. per ton	2	15	0
Oil, 1 gallon, at 3s. 1d.	0	3	1
Waste, 4lb., at 2d.	0	0	8
Depreciation on stationary engine, 10 per cent. on £300, 11s. 6d. Depreciation of electrical apparatus, 15 per cent. on £500, £1 8s. 10d.	2	0	4
Total	£5	19	1

A saving of over 25 per cent.

The total mileage run is very small, on account of the light traffic early in the year. Heavier traffic will tell very much in favour of the electric car, as the loss due to leakage will be a much smaller proportion of the total power developed.

It will be observed that the cost of the tramway engines is very much in excess of what is usual on other lines, but this is entirely accounted for by the high price of coke, and the exceedingly difficult nature of the line to work on account of the curves and gradients. These causes send up the cost of electrical working in the same ratio, hence the comparison is valid as between the steam and electricity, but it would be unsafe to compare the cost of either with horse-traction or wire rope traction on other lines. The same fuel was burnt in the stationary steam engine and in the tramway engines, and the same rolling stock used in both cases; but, otherwise, the comparison was made under circumstances in favour of the tramway engine, as the stationary steam engine is by no means economical, consuming at least 5lb. of coke per horse-power hour, and the experiments were made, in the case of the electrical car, over a length of line three miles long, which included the worst hills and curves, and one half of the conductor was not provided with the insulite caps, the leakage consequently being considerably larger than it will be eventually.

Finally, as regards the speed of the electrical car, it is capable of running on the level at the rate of twelve miles per hour, but as the line is technically a tramway, the Board of Trade Regulations do not allow the speed to exceed ten miles an hour.

Taking these data as to cost, and remembering how this will be reduced when the water power is made available, and remembering such considerations as the freedom from smoke and steam, the diminished wear and tear of the permanent way, and the advantage of having each car independent, it may be said that there is a future for electrical railways.

We must not conclude without expressing our best thanks to Messrs. Siemens Bros. for having kindly placed all this apparatus at our disposal to-night, and allowing us to publish the results of experiments made at their works.

ON MICROPHONIC CONTACTS.*

BY SHELFORD BIDWELL, M.A., LL.B.

It is generally admitted that the variation of the electrical resistance of two conductors in contact, under different degrees of pressure, was first observed by M. du Moncel, whose researches on the subject were published in 1856. This principle was applied ten years later by M. Clerac in the construction of rheostats, the resistance of which was varied by the pressure of a piston upon powdered carbon contained in an insulating tube. In July, 1877, Mr. Edison took out a patent for his celebrated telephone transmitter, in which the varying pressure of a tympanum or diaphragm upon a semi-conducting material was used to regulate the strength of an electric current in such a manner as to render it capable of reproducing speech in a suitable receiver.

* A paper read at the meeting of the Society of Telegraph Engineers, April 12, 1883.

On May 9, 1878, a very remarkable paper was read before the Royal Society by Professor Hughes. It was entitled "The Action of Sonorous Vibrations in Varying the Force of an Electric Current," and contained descriptions of a great number of experiments, which showed in effect that apparatus of the very simplest description, consisting merely of loose contacts of any substance which would conduct electricity, could be used, not only for transmitting speech, but for rendering audible in the telephone sounds which to the unassisted ear were quite inappreciable. It is to this latter property that the microphone, with which the name of Professor Hughes will always be associated, owes its title.

Though at the present time the matter is of great practical importance, there is much in the details of the behaviour of microphonic contacts which has not hitherto been fully investigated or satisfactorily explained; and it was for the purpose of throwing some little additional light on the subject, and, if possible, clearing up certain apparent anomalies connected with it, that the experiments described in this paper were undertaken.

Loose contacts are proverbial for the uncertainty of their action, and it was to be expected that the investigation would prove troublesome, and the results obtained by no means uniform. But by multiplying experiments, the element of uncertainty has been to a great extent removed, and several interesting facts, not, I think, previously noticed, seem to be clearly established.

The first requisite was an instrument for accurately measuring and regulating the pressure between the conducting materials. Several devices were tried, and successively abandoned as unsatisfactory. The arrangement which was finally adopted, and which was used for nearly all the experiments, is shown in Fig. 1. The apparatus consists of a little balance. H K is a light steel rod (formed of a fine knitting needle), balanced at C on a knife-edge which is fixed at right angles to it. To one end, K, is attached a split tube of thin copper for holding short rods of the different substances to be tested, which are held so as to press at right angles upon another rod, R, held in a spring clamp. Midway between C and K is hung the scale-pan S, and at H is a sliding counterpoise, which at the beginning of an experiment is so adjusted that a weight of ·01 gramme in the scale-pan will just bring K and R into contact with each other. Electrical connection is made through the wires W_1 and W_2, the former of which is attached to the clamp holding R, and the latter communicates with a mercury cup, into which dips a wire attached to the rod H K at the point C. It is evident that the pressure between K and R will be equal to half the weight in the scale-pan S.

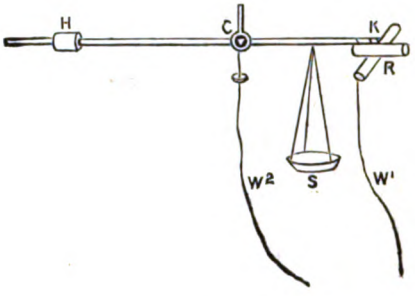

Fig. 1.

The object of the first experiments was to ascertain the effects of various pressures upon the resistance of two carbon rods in the positions shown at K and R, the measurements being made with a Wheatstone bridge in the ordinary manner. The rods selected were electric light pencils of gas carbon, 6 mm. in diameter. In all, seventeen series of observations were thus made, the weights in the scale-pan varying from ·5 gramme to 100 grammes. The mean of three of these, which were performed with the same balance, and under as nearly as possible the same conditions, is given in the following table:—

Table 1.

Relation between the pressure of carbon contacts and their resistance when measured in the ordinary way.

Pressure.	Resistance.	Pressure.	Resistance.
Grammes.	Ohms.	Grammes.	Ohms.
·25	16·10	5	4·23
·5	11·00	7·5	3·53
1	8·43	10	3·06
1·5	6·70	12·5	2·80
2	6·15	15	2·60
2·5	5·90	17·5	2·46
3	5·13	20	2·33
3·5	5·00	25	2·16
4	4·60	50	1·86
4·5	4·33		

In making these measurements the details of the arrangements were from time to time varied. Different proportional coils were used and different numbers of battery cells, and it soon became evident that the resistance of the carbon contact was largely dependent on the electromotive force or the strength of the current used.

Table II. gives the means of two series of observations, and shows the result of using one, two, three, and four cells successively.

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TABLE II.

Effect upon resistance of increased electromotive force.

Pressure.	Resistance in ohms with			
	1 cell.	2 cells.	3 cells.	4 cells.
Grammes.				
·25	11·10	7·20	4·70	3·55
·5	5·95	4·70	4·10	3·50
1	4·40	3·65	3·25	3·10
1·5	3·60	3·20	2·95	2·80
2	3·55	3·15	2·80	2·50
2·5	3·35	2·95	2·65	2·40
3	2·90	2·55	2·35	2·30
3·5	2·45	2·30	2·05	1·95
4	2·25	2·10	2·00	1·90
4·5	2·10	1·95	1·85	1·75
5	1·95	1·85	1·75	1·70
7·5	1·55	1·55	1·50	1·55
10	1·50	1·45	1·40	1·35
25	1·15	1·05	1·05	1·05

It became interesting to ascertain what would be the effect of making still further variations in the strength of the measuring current. A box of resistance coils was, therefore, inserted between the battery (2 Leclanché's) and the bridge arrangement, and, the weight in the pan remaining the same, various resistances were successively unplugged in the box. Table III. gives a few of the measurements with pressures of ·5, 2·5, 7·5, and 25 grammes. This table shows that the resistance of the carbon contacts varies greatly with the strength of the current when the pressure is small, and but very slightly when the pressure is great.

TABLE III.

Effect of varying current by inserting resistance between the battery and the bridge.

Added resistance in circuit.	Pressure between carbons.			
	0·5 gramme.	2·5 grammes.	7·5 grammes.	25 grammes.
Ohms.				
0	5·6	2·7	1·7	1·02
5	—	2·8	1·8	1·03
10	6·9	2·9	1·8	1·03
50	7·7	3·1	1·9	1·03
100	8·6	3·1	1·9	1·03
500	9·3	3·1	1·9	1·03
1,000	9·7	3·1	1·9	1·03

It is clear, therefore, that the diminution of resistance which occurs when the pressure between carbon contacts is increased is not under ordinary circumstances due solely to the increase of pressure; for the diminished resistance which results from the increased pressure causes an increase in the strength of the current, the effect of which is a still further fall in the resistance. Thus, the total diminution of resistance is due only partly to increase of pressure, and partly also to increased strength of current.

An experiment was devised for exhibiting this effect in a conspicuous manner. The arrangement of the apparatus is shown in Fig. 2. a, n, a

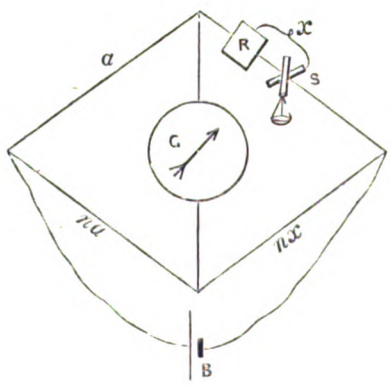

FIG. 2.

$n\,x$, and x are the arms of an ordinary Wheatstone bridge arrangement, B is a battery, and G a reflecting galvanometer. In the arm x is placed the carbon balance S, and in the same arm a box of resistance coils, R; at a is a resistance of 2 ohms, and at n a 1,000 ohms. All the resistance being plugged out of R, the resistance of S, with a weight of 1 gramme in the scale-pan, was found to be 6·4 ohms. Two grammes were then put in the scale-pan, and the resistance fell to 5·1 ohms. In order to ascertain how much of this effect was due to increased strength of current, a resistance was inserted at R sufficient to reduce the current to its original strength—that is, in the present case, sufficient to make the total resistance, S + R, equal to the original resistance of 6·4 ohms. Now, in order to bring up the total resistance to 6·4 ohms, it was found necessary to insert at R, not 1·3 ohm, as might have been expected, but exactly 1 ohm. The resistance of the carbon alone was now (6·4 ohms — 1 ohm =) 5·4 ohms, a weight of 2 grammes being in the scale-pan, but the current the same as when only 1 gramme was in the scale-pan. The further reduction of 0·3 ohm when the measurement was made without the added resistance was due to the increased strength of current consequent upon the increased pressure.

A similar arrangement was then used for determining the resistance of the carbon contacts under gradually increasing pressure, but with a constant current. If E denote the electromotive force of the battery, and B its internal resistance, then the current through the arm containing S will be

$$\frac{n}{n+1} \times \frac{E}{B + \dfrac{n\,(a+x)^2}{(a+x) + n\,(a+x)}}$$

or

$$\frac{n\,E}{(n+1)\,B + n\,(a+x)}$$

From this it is easy to determine what resistances should be inserted in the several branches of the bridge in order to obtain a current through x (and, therfore, through the carbon contacts) of any definite strength. For example, suppose that the electromotive force of our battery is 5 volts, its internal resistance 4·5 ohms, that $a = 10$, $n = 100$, and $n\,a = 1{,}000$, and that we desire a constant current of $\frac{1}{10}$ ampere, then we shall have $\frac{1}{10} = \frac{500}{100\,(x+10) + 101 \times 4{\cdot}5}$. Whence $x = 35{\cdot}5$ nearly

We therefore put a resistance of (35·5 × 100 =)3,550 ohms in the branch $n\,x$, and adjust the resistance in the box R, until the galvanometer indicates a balance. We then know that the resistance of R and S together ($= x$) is 35·5 ohms, and that a current of $\frac{1}{10}$ ampere is passing through R and S. In order to find the resistance of S alone, it is simply necessary to subtract from 35·5 ohms the unplugged resistance in R. It will be understood, therefore, that the resistance in $n\,x$ remains unchanged throughout the experiment, the measurements being made by varying the resistance in R until a balance is obtained.

In Table IV. are given the results obtained with constant currents of ·1 and ·001 ampere, the pressure at the point of contact increasing from ·05 gramme to 25 grammes, all of them representing the mean of several series of measurements. It will be seen that with small pressures the resistance is largely dependent on the strength of the current, but when the pressure is considerable the resistance with weak and strong currents is nearly the same.

TABLE IV.

Effects of pressure upon resistance of carbon contacts with constant currents.

Pressure.	Resistance of contacts.		Pressure.	Resistance of contacts.	
	With ·1 ampere.	With ·001 ampere.		With ·1 ampere.	With ·001 ampere.
Grammes.	Ohms.	Ohms.	Grammes.	Ohms.	Ohms.
·05	11·02	68·00	4	3·63	5·70
·25	9·27	25·50	4·5	3·41	4·95
·5	8·45	17·75	5	3·31	4·95
1	6·56	11·75	7·5	2·95	3·65
1·5	5·53	9·75	10	2·51	3·15
2	5·34	7·50	15	2·10	2·45
2·5	4·57	6·50	20	1·89	2·10
3	4·15	5·85	25	1·67	1·75
3·5	4·03	5·70			

The same effect may be exhibited in another form by varying the current when the pressure remains constant.

Table V. shows the variations in the resistance with currents of from ·01

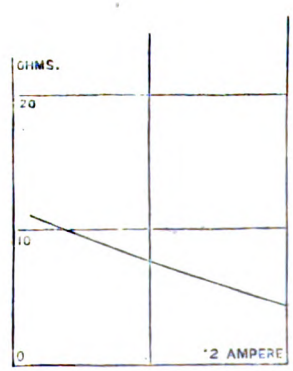

FIG. 3.

ampere to ·2 ampere, the pressure at the point of contact being maintaine at gramme. The results are also shown in the curve, Fig. 3.

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TABLE V.

Resistance of carbon contacts with different currents, the pressure remaining constant at 1 gramme.

Current.	Resistance.	Current.	Resistance.
Ampere.	Ohms.	Ampere.	Ohms.
·01	11·4	·07	8·5
·02	10·8	·08	8·2
·03	10·4	·09	7·9
·04	9·8	·1	7·6
·05	9·6	·15	5·6
·06	8·9	·2	4·5

A few experiments were made in order to ascertain whether the diminution of resistance under pressure was entirely of a temporary nature, or whether it continued in any degree after the pressure had been removed. It was, of course, necessary to guard against the slightest disturbance of the carbon contacts, and it was found to be exceedingly difficult to remove weights from the scale-pan without risk of causing a material amount of vibration. The arrangement which was finally employed, and which proved to be fairly satisfactory, was as follows:—A 5-gramme weight was attached by a thread to one end of a horizontal lever and placed in the scale-pan, the lever being so fixed that when the other end of it was depressed the weight was raised about a centimetre above the pan; it could thus be taken out and replaced without causing any appreciable oscillation.

A weight of 1 gramme being in the scale-pan, the resistance of the contact was measured with the Wheatstone bridge and one Leclanché cell; the 5-gramme weight was then lowered into the pan, and a measurement made of the diminished resistance. The 5-gramme weight was again gently raised, and the resistance with a single gramme once more measured. In every case it was found to have returned almost exactly to its original value. Table VI. gives six series of measurements thus made.

TABLE VI.

Showing effect upon resistance of increasing and again reducing pressure

One Leclanché. Proportional coils 10 and 1,000 ohms.

Pressure.	Resistance.					
Grammes.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
·5	19	20	20	19·6	19·3	19·2
3·0	15	15	14	13·9	13·7	13·6
·5	20	20	20	19·9	19·5	20·0

The experiment was repeated with a resistance of 300 ohms between the battery and the bridge, that the current might be smaller. The results are contained in Table VII., and are substantially the same as before. It will be noticed, however, that the final resistance is almost invariably slightly higher than the original resistance, but this increased resistance gradually diminished, as may be seen by comparing the last figure of one line with the first of the next, and perhaps, if time were given, it would return to its original value. There is little doubt that this is a thermo-electric effect.

TABLE VII.

Same arrangement as in Table VI., with a resistance of 300 ohms between battery and bridge.

Pressure.	Resistance.					
Grammes.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
·5	30·1	31·5	31·6	34·4	35·4	34·1
3·0	24·3	25·2	19·0	19·6	19·8	18·8
·5	32·9	33·2	34·4	36·4	35·1	36·4

Since, as is well known, the resistance of a continuous conductor of carbon is diminished by heat, it might perhaps be supposed that the diminution which the resistance of carbon contacts exhibits under the influence of increased currents is due simply to the heating effect of the current. Experiments made with the view of testing this hypothesis failed, however, to support it. The carbon balance, with a weight of 2 grammes in the scale-pan, was placed in an air-bath, the bulb of a thermometer being very near the points of contact; the temperature was slowly raised, and the resistance was from time to time measured in the ordinary way. At 16deg. (the temperature of the room) the resistance was 9 ohms. As the temperature rose the resistance varied irregularly, increasing, however, on the whole, and never becoming less than it was at first, until at 50deg. it had become 10·7 ohms.

The experiment was repeated with a weight of 10 grammes in the scale-pan. The resistance at 17deg. was 4·7 ohms. As in the former case, the resistance rose and fell irregularly as the temperature increased until 31deg., when it was 4·7 ohms—exactly the same as at first. From this point it increased with great steadiness and regularity to 5·7 ohms at a temperature of 50deg.

It seemed possible that the irregularities in the results might be due to expansions and contractions of the steel beam of the balance, owing to which the upper carbon would be caused to slide over the lower, and thus form fresh points of contact of different resistances. Another arrangement was, therefore, made, which is shown in Fig. 4. Across a fixed carbon rod, 6 mm. in diameter, was suspended a smaller piece, having attached to it a wire of the shape shown in the figure, which dipped into a mercury cup. The total weight of the top carbon and the wire was made equal to 1 gramme.

The resistance of this combination at a temperature of 15deg. was 11·9 ohms. When the bath was heated, the resistance at first began to fall steadily, becoming 11·4 ohms at 20deg., but from this point it again rose, and with some irregularities continued to rise until a maximum of 15·6 ohms was reached at a temperature of 36deg. The bath was then left to cool. As the thermometer fell, the resistance at first rose for a short time, being 16 ohms at 34deg. Then it fell with great steadiness and regularity to 14·2 ohms at 24deg., when the observations were discontinued. Other similar experiments were made, with equally inconclusive results. So far as they are worth anything, they tend to show that the resistance of a carbon contact is increased, instead of being diminished, by heat.* This may possibly be due to the formation of

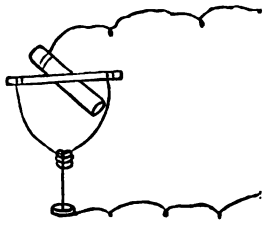

FIG. 4.

a non-conducting film by air or gases which the heat expels from the carbon. The reduction apparently produced by current in the resistance of the contacts is probably quite unconnected with its heating effect, and may be due in part to increased electromotive force.

Under certain circumstances the current appears to produce a permanent and not merely temporary effect upon the resistance; that is to say, the resistance of the contacts is found to be lower (or higher) after the current has ceased than it was at first. The following are a few typical cases:—

A weight of one gramme being in the scale-pan, the resistance of the contacts with a small current (one or two milli-amperes) was 10·5 ohms. A current of ·15 amperes (measured by a tangent galvanometer) was then passed through the carbons for ten seconds. On afterwards testing with the small current, the resistance was found to have fallen to 5·8 ohms. The carbons were then separated by gently raising the scale-pan for a few moments, and carefully replaced in the same position as before. The resistance was now 10·6 ohms, or almost exactly the same as at first. With 5 grammes in the scale-pan, the same current reduced the resistance from 6·6 to 4·3 ohms. With 10 grammes the resistance was permanently reduced from 4·7 to 3·4 ohms, and with 50 grammes from 2·4 ohms to 2 ohms. All these effects were produced by a current of ·15 ampere. Stronger currents (up to a certain point) effect greater reductions.

But when the proportion of the current strength to the pressure at the points of contact exceeds a certain limit, the effect of the current is apparently to produce a permanent *increase* in the resistance, and this increase is sometimes very considerable. Thus, for example, with a weight of 5 grammes the resistance was 6 ohms; after a current of ·6 ampere (four times as strong as in the preceding experiments) had been passed through the carbons for ten seconds, the resistance, measured with a small current, appeared to be about 200 ohms, falling in three minutes to 35·9 ohms. These latter measurements, however, afterwards turned out to be partly illusory; for a tangent galvanometer, placed in circuit with the carbon, shows that the effect of a current beyond a certain strength is really to render the resistence infinite, or at least very great. The resistance does not rise gradually, but suddenly, generally after the circuit has been closed for from two to ten seconds, and at the moment of the rise a minute flash of light appears at the points of contact. The galvanometer needle suddenly goes to zero, and when this has occurred no deflection whatever is produced on opening and closing the circuit with a key. A slight vibration, however, partly or wholly restores the conductivity of the carbon, and, curiously enough, the

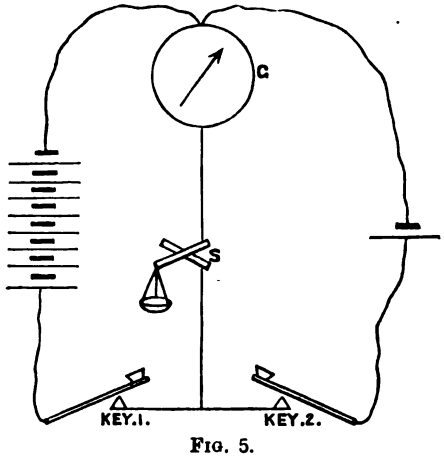

FIG. 5.

ame effect is often produced by the feeble current used to measure the resistance. Thus it may happen that, while the moment before measurement the resistance may be infinity, the very act of measurement reduces it to a few hundred ohms.

This curious effect is best shown by the special arrangement indicated in Fig. 5. G is the tangent galvanometer, S the carbon balance, in the

* I take it as being beyond dispute that the resistance of a *continuous* carbon conductor is diminished by heat. A Swan lamp being placed in the air bath, the resistance of the carbon filament steadily fell from 80·9 ohms at 19deg. to 76·5 ohms at 100deg., following the received law.

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scale-pan of which is a weight of one gramme. When key 1 is depressed, the current from 8 Leclanché cells passes through the galvanometer and the carbons. The immediate effect is a deflection of (in the case of the galvanometer used) about 75deg. Almost instantly, however, the needle returns to zero, and key 1 may be now raised and depressed without producing the slightest movement of the needle. If, however, key 2 is depressed, it frequently happens that the current from the single cell will pass through the galvanometer and the carbons, producing a small deflection of from 2deg. to 10deg. But if key 1 is once more depressed, the needle again altogether fails to move.* The resistance at S is therefore of a very peculiar nature, being more easily overcome by a small electromotive force than by a high one. Though I have successfully performed this experiment some scores of times, it occasionally happens that the single cell is as powerless to overcome the resistance as the larger battery.

The group of phenomena last described were now investigated systematically. In the first place the arrangement shown in Fig. 6 was used, the

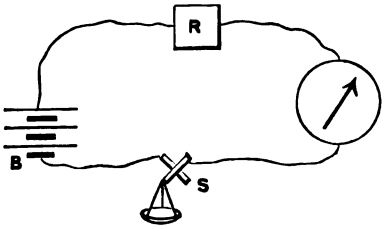

FIG. 6.

carbon balance, a tangent galvanometer, and a box of resistance coils being arranged in simple circuit with a battery of 10 Leclanché cells. Various weights were put in the scale-pan, and resistance was gradually taken out of R until the sudden rise in the resistance of the carbon contacts occurred, the galvanometer reading immediately before it went to zero being noted. The results are given in Table VIII., the pressure at the point of contact ranging from ·05 gramme, when the sudden rise occurred with ·02 ampere, to 5 grammes when the rise occurred with ·63 ampere.

TABLE VIII.

Showing for various pressures the smallest current which produced a sudden great rise in the resistance of the carbon contacts.

Pressure.	Smallest current with which rise in the resistance occurred.	Pressure.	Smallest current with which rise in the resistance occurred.
Grammes.	Ampere.	Grammes.	Ampere.
·05	·02	1	·40
·1	·05	1·5	·43
·15	·10	2	·47
·2	·19	3	·57
·3	·17	4	·51
·4	·29	5	·63
·5	·37		

It will be remembered that before the sudden rise an increasing strength of current effects a permanent reduction in the resistance of the carbon. For examining this effect the apparatus was arranged as shown in Fig. 7. It is essentially a Wheatstone bridge arrangement, the proportional coils

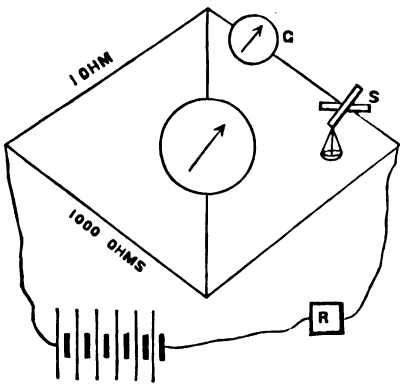

FIG. 7.

used being 1 and 1,000 ohms. A tangent galvanometer of ·9 ohm resistance is inserted in the same arm as the carbon balance, and a box of resistance coils, R, is placed between the battery (which consists of 8 or 10 Leclanché cells) and the bridge. The arrangement admits of the measurement of the resistance of the carbon when traversed by strong currents, the strength of which can be regulated by the resistance box R, and measured by the tangent galvanometer G. A given weight being in the scale-pan, known currents of gradually increasing strength were passed through the carbon. The resistance was measured, 1st, while the known current was passing; 2nd, with a very small current, obtained by unplugging 10,000 ohms in the resistance box. As the currents increased in strength, the resistance, measured with the very small current, gradually diminished until a point was reached—and the lighter the weight the sooner this was the case—at which the resistance suddenly became infinity. The measurements are given in Table IX., the currents varying from ·01 to ·7 ampere, and the pressures from ·05 gramme to 5 grammes.

* In order to avoid the effect of possible vibration, the keys should not be on the same table as the carbon balance.

(TO BE CONTINUED.)

THE EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY (LIMITED).

The nineteenth ordinary general meeting of this Company was held on Wednesday, the 18th inst, at the City Terminus Hotel, Cannon-street, under the presidency of John Pender, Esq., M.P. The secretary (Mr. F. E. Hesse) read the notice convening the meeting, and the minutes of the eighteenth ordinary general meeting, held November 1, 1882, which were confirmed, and signed by the chairman.

The CHAIRMAN: You have had the report in your hands for some time. I presume you will take it as read. Well, I shall refer to some of the leading points in the report, so that I may show you clearly the fluctuations during the past six months. The gross receipts for the half year have amounted to £209,131, against £205,963 for the corresponding period of 1881, or an increase of £3,168. The working expenses are £54,782, against £51,643 for the corresponding period, or an increase of £3,139. This is principally caused by station expenses, showing an increase of something like £1,400, in consequence of larger travelling expenses having been incurred in bringing home and shifting about the foreign staff, and through the cost of repairs to the cables being £1,200 in excess of that in the corresponding period. The net revenue has been £110,755, against £76,970, showing an apparent increase of £33,785. But during 1881 a sum of £34,000 was taken from revenue towards the renewal of the Batavia cable, to which I fully referred at the last and the previous meetings, consequently the net revenue for the half year under review is practically the same as it was during the corresponding period of 1831. If, however, the figures for the whole year are considered, the following satisfactory results are shown:—Gross receipts of 1882, £416,250, as against £397,543 in 1881, giving an increase of £18,707. The working expenses of 1882 were £105,137, as against £105,741 in 1831, showing a decrease of £604 for the year [applause]. The net revenue for 1882 was £194,148, as against £171,725 in 1881, showing an increase of £22,423 [applause]. For the past half-year 1½ per cent. dividend, amounting to £24,968 15s., has been paid, and it is now proposed to distribute another dividend of like amount, together with a bonus of 2s. per share, which, with the previous payments for the first half, will make a total distribution of 6½ per cent. for the year 1882, as against 6 per cent. for 1881. The sum of £64,311 has been added to the reserve fund for the year, increasing that fund to £351,033. I may mention, gentlemen, that since these accounts were printed we have invested a further £100,000 for the reserve fund, which will appear in the next half-yearly statement. £50,000 of this is from the earnings of the Company, and £50,000 is the premium which we made upon the issue of our new shares, so that you will observe that our reserve is getting to a very goodly sum indeed. A sum of £30,000 has also been taken from revenue during the past year, besides £34,000 in the previous year, towards the renewal of the Singapore-Batavia cable, but for which the reserve fund might have been further increased by that amount, or a portion of it applied to increase the dividend, and the balance carried to the reserve fund. We have also spent out of revenue during the last four years, in addition to the sums already alluded to, £35,585 in renewing various portions of the Company's cables, involving an expenditure of 1,800 knots of cable. At the same time we have picked up 1,600 knots, which have been taken into the cable account at a depreciated value before arriving at this result. All this has been done to improve our system and to strengthen our position as a dividend paying concern. Our system now consists of 11,250 knots of cable, of which about 1,800 knots are more or less exposed to the action of the teredo. This, you will understand, has been the little foe we have had to fight, and it has been persevering to a degree which it is almost difficult to explain. But I think we have conquered it at last. I think with the ribbon cable—this yellow portion of the cable (exhibiting a piece of the cable to the shareholders)—we have so far been able to beat our enemy. We have done this, so far, entirely out of revenue. We have not added one shilling to capital in improving our system—in taking up what was bad and replacing it with what we consider an armour-plated cable against the teredo. Of the 1,800 knots of cable more or less exposed to the action of the teredo, 825 knots have been replaced by brass-ribboned cable, leaving nearly 1,000 knots still to be replaced, and we propose doing this as opportunity occurs, putting in new pieces, and taking up the old, and we shall be able to utilise the portions picked up in other directions. I may mention that the shares we issued (50,250) were readily taken up by the shareholders at £1 premium, and since the report was issued the committee of the Stock Exchange have granted a special settlement and quotation for the shares. Now I think, so far as figures go, I have shown you a very good account of your affairs, and I think I may say, looking to the fact that we have so far secured ourselves against the teredo, that with the amount we have now got to the reserve, and with the almost immediate prospect of seeing our reserve fund stand at half a million sterling, I think it is, perhaps, not too sanguine to say that if we have the same success during the next six months that we have had during the last year we may probably be able to add as much to the dividend next year as we have done in the past year [applause]. Now, gentlemen, there is a question that comes up which is personal to the Board and myself, and which you will observe is referred to in the report. Some 18 months ago Colonel Glover died. He was then managing director of the Company, and in receipt of £1,500 a year. I stated on that occasion that, constituted as we were, I hoped we should be able to conduct the affairs of the Company with perfect satisfaction to all concerned without appointing a successor. I think I may say we have done so very successfully, for perhaps in no period of the Company's history has it been more successful than it has been during the past eighteen months. And I may say that the managing direction, so far as it goes, involves a day to day, if not an hour to hour attendance on the part of myself and those around me whom I choose to call to my assistance at any time, and who are always ready to respond. The affairs of the Company have been carried on in such a way that we think we are justified, having saved in the first place £1,500 a year,

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in having reverted to the original sum which was granted to the directors, viz., £4,000 a year. We reduced that amount for a considerable time, as you are all aware, when we were not paying as high a dividend as we considered we ought to pay. But now that we are giving I hope not a very excessive but a fair and increasing dividend we think it is not unjust that we should share with you a little of the prosperity. Therefore, I think it better to be straightforward, and to tell you exactly the reasons that we have for doing it, and I hope that as our affairs are altogether prosperous you will not grudge that which we have taken the liberty of placing into the accounts—in other words, of reverting to that which we had a right to, but which we gave up for a time [applause]. Now, gentlemen, during the year we have had several repairs, as usual. If we could only do away with those repairs I cannot tell you what good we might do, and how much benefited you would be; but, after all, we must meet them, and fortunate we are in being able to meet them—that is in knowing that we have a property which really, when an accident occurs, we know that we can mend. We have at the present moment (and this shows the enormous importance of duplicating our cable) one of our cables to Australia interrupted. We have just received a communication which will lead us to believe that in a comparatively short period it will be repaired; but for some days it has been interrupted, and in grappling for the one we got the other, and a very singular circumstance occurred. We actually had to take the end of the old cable, attach it to the other end of the new, and carry on the traffic for some time in this manner. You see when we lay a cable in the depths of the sea it is not easy to say where it will be twelve months hence. At all events, we have found that cables have drifted five or six miles from the point indicated on the chart. Still, all this shows that we have a property which we can control and repair when accidents occur. Now, there is another important point I have to mention. Since I last had the pleasure of addressing you we have carried out a very successful enterprise in establishing a line of cable from Hong Kong to Shanghai. When this Company was originally formed it was our intention to make our northern terminus at Shanghai. But when we had laid our cable from Madras to Penang, Singapore, Cochin China, and Hong Kong, intending to carry it on to Shanghai, we were more or less anticipated by the Great Northern Company, whose line passes through Russia, and who share with us the China traffic at the present moment, by their laying a cable between Hong Kong and Shanghai. We felt they were trenching on our ground. We intimated this to the Great Northern Company, and they prudently, I think, took our view that where one cable would do the work there was no use laying down a second one. We therefore came to an arrangement with the Great Northern Company by which we shared with them the benefit of the cable they had laid down. That has continued now for twelve years. We have found from experience that one cable does not give the permanent service which we now desire to give to those who use the submarine telegraph, and there was a very strong expression of opinion among the commercial community of Shanghai and Hong Kong that the existing service was not satisfactory, and they threatened to form a co-operative company for the purpose of laying and working a cable of their own. I felt that this would be an interference with our rights, and putting two links in a chain where one was quite sufficient for the continuity, and therefore I at once communicated with the Great Northern Company, stating that the time had now come when it was necessary that this system should be duplicated by a cable to be laid and worked by our Company. There was great opposition on the part of the Great Northern Company to our establishing this line to Shanghai, but we had made up our minds. We had ordered the cable, and we sent our ship off. The result was that negotiations took place. The old treaty was re-considered, and we have now entered into a fresh one with the Great Northern Company for a considerable number of years by which we, the Eastern Extension Company, are to share with them what we did not before, namely, all the privileges which they hold north of Shanghai and the Japanese traffic. We were very decided about having our terminus at Shanghai, for the simple reason that within the last two or three years China has given very marked evidence of making progress in the direction of European civilisation, and if China is opened up, and if the telegraph system which the Chinese are projecting is carried into effect, it will be a wonderful feeder of our system. We therefore felt that if we gave up Shanghai we should give up a very great hold upon traffic which we considered we were entitled to have—because the English trade at the present moment with China is something like 80 per cent. of the whole traffic. Consequently we felt that it would be impossible for us to allow that traffic to pass into hands which might, in some measure, retard the commercial relations between the two countries in the way we shall always endeavour to promote by our grand system of international telegraphy. The result of the whole thing has been that we have entered into this arrangement with the Great Northern Company, and our cable is now laid. We have had difficulties to encounter; not so much in landing it, but as to the point at which we ought to land it. I think, however, that in a few days these difficulties will be overcome, and our system opened for traffic, and I look for a considerable profit from this important negotiation, and if the arrangement is loyally carried out, I believe it will benefit not only the two companies, but also those who are telegraphing from China to Europe, by giving a more permanent, certain, and better system. I think, at the same time, that China will be benefited. There is just one other point before I leave China. We have an important station at Hong Kong, and the Chinese are likely to carry to Canton the land line system they are now projecting, and we have made arrangements whereby we shall connect with that system, and work the telegraph coming from China to Canton and Kowloom—the border where Chinese territory ends and English territory begins. Therefore, looking at it all round, I think we have in our grasp all that vast system of telegraphy which, if well used, will be beneficial to all. There is another movement that we have made since I last had the pleasure of addressing you. We have entered into negotiations for carrying our system from Penang to Bangkok, the capital of Siam. We have obtained a concession for forty years, which ought to give us, at all events, a traffic that will pay for the expense we are going to incur in carrying out this work. It will not be a very large feeder, but I think it will strengthen our hands still more. I trust that the next time I have the pleasure of addressing you I shall be able to state that this connection has been completed. With these remarks, gentlemen, I beg to move, "That the report and accounts of the directors now submitted be received and adopted, and that a dividend be now declared of 2s. 6d. per share, together with a bonus of 2s. per share, both free of income-tax, payable on the 18th inst., making, with the previous distribution, a total payment of 6½ per cent. for the year 1882."

The Marquis of TWEEDDALE: I have much pleasure in seconding that.

The CHAIRMAN: Now, gentlemen, before I put that resolution, if any shareholder in the body of the hall has anything to say I should be very glad to listen to him, and to give the best reply in my power to any point raised.

Mr. GRIFFITH: I am sure that we must feel obliged to you for your lucid statement, and we must all be gratified at the announcement that the reserve has now attained to such a sum that we may hope in the future to have an increased dividend in addition to that paid on the present occasion. I have been looking over the accounts, and there was one point that occurred to me, namely, that our reserve fund does not produce much beyond 3 per cent. Of course, our reserves ought to be invested in good securities; but it does occur to me, now that we have so large a reserve fund, whether it would not be desirable in future, instead of adding to that fund, to use our surplus revenue in paying off some of our debentures. I put this rather tentatively than otherwise, as I know that debentures are drawn in different forms. Some are drawn as debenture stock, others as debentures that must run for a certain number of years, and in other cases they are drawn as debentures payable to bearer. As we pay 6 per cent. and 5 per cent. for our debentures, and only receive a little over 3 per cent. from our reserve fund, it seems to me that it might be advantageous if, in the future, we were to pay off some of those debentures (this is on the supposition that there are any payable to bearer), and so save a large amount of interest every year. That would increase our income by the mere exercise of an economical arrangement, and would not in any way prejudice us, for we have already a reserve fund which will shortly amount to £500,000, and we may look to the position of the Company as a stable one, the dividends of which will be progressive, and largely in excess of the dividends paid in the past. There was another point you have referred to in connection with the death of Colonel Glover. We are glad to find that the Board are able to carry on the business as successfully as in former times, and that both the stability and business of the Company are increasing. We find by the report that the receipts are in excess of what they were last year, and your statement shows reasons for our expecting a still greater excess. We may congratulate ourselves upon this state of matters, and I think it would be very unfair on our part if we declined to give a share of our prosperity to those who have been instrumental in bringing about these most satisfactory results. I think we are not only indebted to you for the last dividend, but for the intelligence displayed in connection with the future of the Company by bringing us into relations with a country that is now adopting habits of civilisation—China. I have had the pleasure of meeting the ambassador of that country, and I can say that the desire of the educated classes of China is different now to what it used to be. Before, they were exclusive, but they are now adopting many of our principles of international law, and principles of policy, and anything that we can do to add to their benefit will be advantageous not only to them but to us. I hope we shall show our gratitude to the directors by consenting to the remuneration mentioned.

The CHAIRMAN: Gentlemen, you have heard Mr. Griffith's remarks upon the financial position of the Company. We are watching this very closely, and as our 6 per cent. debentures will expire by and by, we hope to replace them at a lower rate of interest; but, notwithstanding that, I do not think it would be prudent to lose sight of the reserve fund. It is a grand stand-by. You could not have your shares at their present premium if you were to wipe out the reserve fund even in the manner suggested by Mr. Griffith. I speak with the most perfect confidence as to our telegraph system. Still, I feel if we had to renew any part of it, it would be a grand thing to have our reserve fund to fall back upon. However, I think when we get it up to such a point as half a million, or more, probably the interest upon it might form a portion of the dividend; in other words, that those who are shareholders would derive some profit out of the investments, because we shall always continue to add something to it. If there were a decent sum of interest amounting to half or one per cent., and the shareholders were getting that paid to them out of this reserve fund, it would give them, as it were, two strings to their bow. You would have not only your dividend from this large reserve fund but also from the working of the system.

Mr. JOHN NEWTON: I should like to say one word. I have so often criticised the policy of the Board that I wish to say that I thoroughly appreciate the principle of the Board taking additional remuneration when they have increased our dividend beyond 6 per cent. I am sure the shareholders will not object to pay the directors handsomely when they pay us so good a dividend, and moreover when they promise to pay us even more. You deserve your remuneration in this Company. I do, however, object to the principle of doing away with the managing director. I think a company that has four millions of capital and such a great organisation as this should not be dependent on the life of any one single man, and I do not, sir, admit the principle that your colleagues can take your place at a moment's notice. If they could take your place they could not take the place of a managing director, and it is establishing a wrong principle to my mind to say that you can do without a managing director. If you can do so the other companies can, and that is, I believe, a wrong principle. There should be not only a chairman who takes a very active interest in the Company, but another director to whom the shareholders can look for a large amount of responsibility for the whole organisation—the complete establishment, and the staff; and, therefore, I do think this Company can well afford to pay a managing director handsomely, as well as to pay the Board handsomely when they are giving the shareholders such results as you are giving us, and when you can promise and show us such a prospect of improvement as this Company shows. If you are not now standing at the head of all the telegraphs of the world, I feel that you will soon do so, but I think it would not be prudent for the sake of £1,500 a year to do without the services of a capable and efficient managing director.

The CHAIRMAN: I shall not enter into a discussion upon the views which Mr. Newton has just expressed. All I can say at the present moment

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is that there is a great deal to be done still before we get the system thoroughly completed, and there is a great deal to do that not only requires the daily and hourly attention of your chairman, but also of the other members of the Board on particular occasions. We are working in perfect harmony just now. I have great respect for the opinion that Mr. Newton has expressed in reference to one of our companies. We have carried on that system with wonderful success, viz., in having Sir James Anderson as managing director of the Eastern Company. But at the present time we have such a combination in being all under the same roof that we utilise the good heads round about us, and if we can do that and save a considerable amount of money to the shareholders, I think we are perfectly justified in doing so. All I can say is this, if I saw that you were suffering in the slightest degree, or that the interests of the Company were likely to suffer by the course that we are now pursuing, I would at once adopt the suggestion of Mr. Newton. But meantime I am satisfied that we are throwing a greater responsibility on the directors. A managing director takes off a considerable amount of responsibility from his colleagues, and I wish the directors individually, as well as collectively, to feel that there is a responsibility resting on their shoulders, and I do not wish to relieve them from it, at all events, at the present time. With these remarks I ask you to approve of the resolution I have placed before you. To the contrary. Carried unanimously. I should just say one word with regard to the directors' remuneration. Mr. Newton has been kind enough to criticise—and criticise us very justly. In fact, there is nothing I like so much as good hard criticism, and he has given it us from to time very fairly, and sometimes we have thought a little too hard. But at all events we the more appreciate Mr. Newton's remarks to-day in that they have come from a quarter where the part of the watch dog has been played throughout, and as Mr. Newton approves of what we have done to-day I think we may safely congratulate ourselves on having done that which the general body of the shareholders quite approve.

The Marquis of TWEEDDALE: I have the pleasure of proposing the following resolution, which I am sure you will adopt unanimously:—"That John Pender, Esq., M.P., who now retires by rotation be and is hereby re-elected a director of this Company."

Sir WILLIAM MCARTHUR, K.C.M.G., M.P.: I second the resolution.

The Marquis of TWEEDDALE put the motion, which was carried unanimously.

The CHAIRMAN: Gentlemen, as they say in Scotland, one good turn deserves another, and I have now the pleasure to propose, "That the Most Honourable the Marquis of Tweeddale, who now retires by rotation, be and is hereby re-elected a director of this Company."

Mr. FRANCIS AUGUSTUS BEVAN: I have great pleasure in seconding the resolution.

The CHAIRMAN put the motion and declared it carried unanimously.

The Marquis of TWEEDDALE: I beg to thank you.

The CHAIRMAN: Now, gentlemen, the next resolution will be moved by Mr. Abbott.

Mr. WILLIAM ABBOTT: The resolution has reference to the auditors, and as I do not wish to speak twice, I may say at once what I wish to say as to the question raised by Mr. Griffith in relation to the reserve fund I think that, great as has been your skill in the administration of this Company from time to time, and the recommendations which you have made to the shareholders, which I well remember were vigorously opposed by certain sections of the shareholders, who, by the by, I do not see here to-day, it is well that I should, having some knowledge of this matter, commend you for the care and skill with which you have selected your investments forming the reserve fund. I differ from Mr. Griffith, who says you only get about 3 per cent. return on the investments. You derive considerably more than 3 per cent., and moreover there is a considerable profit on what those investments originally cost you. That is a point very satisfactory to the proprietors. With regard to the suggestions that you should diminish your reserve to pay off your debentures, I cannot imagine any system of finance more ruinous to a company like this, which, to a great extent, like other trading companies, depends largely on its credit. With these remarks I move the re-election of Mr. Henry Dever and Messrs. Quilter, Ball and Co., at a remuneration of £100 each. I wish to inform the shareholders, as I take the responsibility of moving this resolution, that the remuneration is an increase of £50 to each auditor. I think with the increased capital, and the constant progress of the concern, the care they are obliged to exercise over the securities, and the advice which they have, no doubt, to give the Board on many matters, it is only right that we should increase the remuneration of the auditors. They have done their work fairly and well, and it is only right that they should be paid accordingly.

Mr. MARCUS seconded the motion, which was carried.

Mr. ABBOTT: Before we separate I wish to move a hearty vote of thanks to the chairman and directors. The chairman has said that they are all working together harmoniously, and that they avail themselves from time to time of the value of the heads that are under the same roof. I hope, however, they will not draw too much on the brain of Sir James Anderson, for I should be sorry, indeed, to see him deteriorate from the handsome appearance he always presents [laughter]. I propose a hearty vote of thanks to the directors.

Mr. MARCUS: I beg to second the motion.

Mr. ABBOTT put the motion, which was carried.

The CHAIRMAN: There is nothing so pleasant to your Board as to be able to pay an increased dividend and receive your thanks and increased confidence. I beg to thank you on the part of the Board.

Mr. STOKES: I think we should propose a vote of thanks to our secretary and staff, who are helping the directors so well.

The CHAIRMAN: I am quite sure that they will appreciate your kind thought of them, and I can assure you that we do not lose sight of them in the arrangements that we are now making.

The proceedings then terminated.

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 9, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES APRIL 18.		BUSINESS DONE WEEK ENDING APRIL 18. Highest.	Lowest.
Anglo American	51,	52	51¾	51
Do. Preferred	83,	84	84¼	83
Do. Deferred	20½,	21¼	21	20
Brazil Submarine	12¾,	12¾	12¾	12¾
Cuba	10,	10½	—	—
Do. Preference	17,	18	—	—
Direct Spanish	5¼,	5¾	—	—
Do. Preference	15½,	16½	15¾	15¾
Direct United States Cable	12¼,	13¼	12¾	12¾
Eastern Telegraph	10¾,	11	11	10¾
Do. 6 per Cent. Preference	13,	13½	13½	13½
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12,	12¼	123-16	12
German Union	10,	10½	—	—
Globe Telegraph and Trust Company	6¾,	7¼	7¼	7
Do. Preference	12¾,	13¼	13¼	13
Great Northern	12¾,	13¼	131-16	13
Indo-European	32,	33	—	—
Mediterranean Extension	1¾,	2	—	—
Do. Preference	6¼,	7¼	7	7
Reuter's	9¼,	10	9¾	9¾
Submarine	247,	252	—	—
West India and Panama	1⅞,	1¼	1 7-16	1 7-16
Do. 1st Preference	7¾,	8¼	8	8
Western Brazilian	7⅛,	7¾	7¾	7¾
West. Union 7 per Cent. 1st Mortgage	125,	128	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅞,	1	1 1-16	13-16
Oriental	¼,	⅜	—	—
United Telephone	10,	10½	10¼	10

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	5¼,	6	6¾	5 7-16
Do. (fully paid)	7¼,	8¼	9¼	8¼
Harmonic Light	2¾,	3¼	3 9-16	2 15-16
Eastern Electric (fully paid)	—,	—	—	—
Pilsen, Joel, and General Electric	¼,	1	—	—
Swan	1¼,	2¼	2	2
Maxim-Weston	¼,	⅜	5-16	⅜

IN the HIGH COURT of JUSTICE, CHANCERY DIVISION.

IN the MATTER of THE COMPANIES' ACTS, 1862 and 1867, and IN the MATTER of the PHŒNIX ELECTRIC LIGHT and POWER COMPANY (Limited).

The Creditors of the above-named Company are required, on or before the 10th day of May, 1883, to send their names and addresses, and the particulars of their debts or claims, and the names and addresses of their solicitors (if any) to HENRY BISHOP, of 41, Coleman-street, in the City of London, the liquidator of the said Company, and if so required by notice in writing from the said liquidator, are by their solicitors to come in and prove their said debts or claims at the chambers of Mr. Justice Pearson, at the Royal Courts of Justice, Strand, in the county of Middlesex, at such time as shall be specified in such notice, or in default thereof they will be excluded from the benefit of any distribution made before such debts are proved.

Wednesday, the 23rd May, 1883, at 12 o'clock at noon, at the said chambers, is appointed for hearing and adjudicating upon the debts and claims.

Dated this 11th day of April, 1883, E. W. WALKER, Chief Clerk.

Freshfields and Williams, 5, Bank-buildings, London, E.C., Solicitors for the Liquidator.

TO TELEPHONE COMPANIES, &c.—ELECTRICAL ENGINEER and MANAGER.—A GENTLEMAN (aged 30 years) holding Certificates of Qualification from Royal College of Science is open to accept an APPOINTMENT as ENGINEER and MANAGER. Advertiser has had an excellent business training, and could undertake the general management of a Telephone Exchange.—Address, E. M. F., this office.

WANTED.—VOLS. VII. and VIII. of "THE ELECTRICIAN," either bound or in parts. Address, stating price, B. B. H., HARRISON and SONS, 45, St. Martin's-lane, London, W.C.

A GENTLEMAN, thoroughly acquainted with the theory and practice of electricity, wishes for EMPLOYMENT.—J. KING, 15, St. John's-square, Clerkenwell, E.C.

WANTED EMPLOYMENT in LONDON, either paid or unpaid, upon dynamo-machines, by an electrical student, with no practical experience, but ready to make himself useful. Address, W., 21, Herbert-street, New North-road, N.

ELECTRIC LIGHT and POWER.—The Advertiser (Mem. Soc. Tel. Eng.) will be disengaged in June next, wishes an English or foreign APPOINTMENT. Accustomed to erection of machinery and installation of works.

X. Y., office of ELECTRICIAN.

WANTED, ELECTRICIAN and ENGINEER by provincial Electric Lighting Company. Must be skilled in installation work, in practical use of tools, and possess good knowledge of the construction of electric light apparatus; also able to take general management. Salary as arranged, not to be less than £150. Applications, with full references and certificates, to M. A., office of THE ELECTRICIAN, 396, Strand.

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SLIP

THE HAMMOND ELECTRIC LIGHT COMPANY.—The second ordinary general meeting of this company will be held on the 9th May.

ELECTRIC UNITS.—On Thursday, May 3, Sir W. Thomson, F.R.S., M.Inst.C.E., will lecture at the Institution of Civil Engineers on "Electrical Units of Measurements."

CRYSTAL PALACE MANAGERSHIP.—Mr. G. G. Cleather, assistant-manager, has been appointed manager of the Crystal Palace, in the room of the late Mr. G. W. Reay-Mackey.

THE INSTITUTE OF CIVIL ENGINEERS.—This institution now numbers 21 honorary members, 1,347 members, 1,671 associate members, 524 associates, and 774 students, making altogether 4,337.

NEW COMPANY.—The McTighe Electric Light and Manufacturing Company has been incorporated, with a capital of 300,000dols. They are going to erect a large manufactory in Pittsburg, Pennsylvania, U.S.

THE EDISON SYSTEM IN ENGLAND.—The Edison Company of London had installed up to April 6 no less than 4,463 lamps, whilst the Manchester company's installations numbered 3,980, making a total for England of 8,443.

THE SINGAPORE-SAIGON CABLE REPAIRED.—The Eastern Telegraph Company notifies the restoration of the Eastern Extension Company's Singapore-Saigon cable. Messages can again be accepted for China, Japan, Manila, and Cochin China, "*viâ* Eastern."

THE EDISON SYSTEM AT THE AQUARIUM.—The Edison Company have replaced the B or eight candle lamps hitherto shown at the Aquarium Exhibition by A or sixteen candle lamps. The new lamps have a much better effect than those formerly in use.

"JOURNAL OF THE SOCIETY OF TELEGRAPH ENGINEERS."—The present number of this journal contains Mr. Shoolbred's Paper on "The Measurement of Electricity," Mr. Munro's Paper on "Telephone Transmitters," and other matter of interest.

THE TELEPHONE IN THE WEST INDIES.—The question of introducing the telephone into Georgetown, British Guiana, has for some time past been under discussion. It is now stated that a scheme for the establishment of a telephonic exchange there has been adopted.

REPAIR OF THE ZANZIBAR-MOZAMBIQUE CABLE.—The Eastern Telegraph Company announce the repair of the Eastern and South African Company's cable between Zanzibar and Mozambique, thus re-establishing telegraphic communication with the Cape of Good Hope and Natal.

HONOURS FOR AN ELECTRICIAN.—In announcing last week that Dr. Siemens had been made Sir C. W. Siemens we omitted to state that another well known electrician had had a similar honour conferred upon him by Her Majesty the Queen. Prof. F. A. Abel will in future be known as Sir F. A. Abel.

SECONDARY BATTERIES.—On the evening of May 7 Mr. C. T. Kingzett, F.I.C., F.C.S., will read a paper on "Secondary Batteries" before the Society of Chemical Industry at Burlington House. It is understood that he will, incidentally, give a description of his own improvements in secondary batteries.

CHANGES OF ADDRESS.—The Hammond Electric Light and Power Supply Company have removed their Lancashire offices from 36, Dale-street, Liverpool, to 79 and 80, Hawarth's-buildings, Cross-street, Manchester, the business still being carried on under the general management of Mr. James Shaw as heretofore.—The Vulcanised Fibre Company (Mosses and Mitchell) have removed to their new premises, 68, 69, 70, and 71, Chiswell-street, Finsbury, E.C.

A NEW CABLE.—The Eastern Telegraph Company has now completed its triplicate cable through the Red Sea from Suez to Aden. The cable, the successful laying of which was completed at the end of last week, was manufactured by the Telegraph Construction and Maintainance Company, and is of the most recent type, being brass covered, to guard against the attacks of marine insects. The ships employed in the work were the ss. "Seine" and "Kangaroo."

THE LIGHTING OF LIGHTHOUSES.—The committee appointed by the Board of Trade to determine the relative merits of oil, gas, and electricity as lighthouse illuminants consists of Captain Nisbet, of Trinity House, chairman; Dr. Ball, F.R.S., Astronomer Royal for Ireland; Mr. A. Vernon Harcourt, F.R.S., Dr. Hopkinson, F.R.S., Mr. J. Crichton, Sheriff of Fife; Sir James Douglass, C.E., and Mr. J. R. Wigham, of Dublin. Mr. E. Price Edwards has been appointed secretary to the committee.

WATER POWER GALORE.—California would appear to afford abundant opportunities for exercising the calculating powers of electricians, whose acme of happiness is to utilise the powers of nature constantly running to waste. It appears that there is a fall in the Yosemite Valley, California, which leaps down 1,600ft. at one bound, while there is a second lower fall of 600ft., and yet a third of 434ft. The Sentinel Fall is said to have even a greater leap still. Beside these gigantic efforts of nature, Niagara, with its puny 163ft. of fall, sinks into insignificance.

ELECTRIC LIGHTING ON SHIPS.—It is stated that the Guion Liner ss. "Oregon," now building at Fairfield Yard, Glasgow, is to be fitted throughout with the electric light, and that a spare set of generating plant is to be kept in reserve for any emergency that may arise. The contract for the work has been concluded between the owners and the Edison Company. Five hundred A (6 c.-p.) lamps will be employed. It is the intention of the Guion Line that the "Oregon" shall beat her sister ship the "Alaska" by six hours, and so still further shorten the trip across the "herring pond."

ELECTRIC LIGHTING IN PENTONVILLE-ROAD.—This road has for some time past been lighted by means of Maxim incandescent lamps, a pair of which are fitted inside each lamp post in place of the ordinary gas burner. It appears that the Clerkenwell Vestry are not at all satisfied with the lighting by the incandescent system, and accordingly the Maxim-Weston Company have offered to substitute 10 Weston arc lamps of 1,500 candle-power for the present lamps, at a cost to the vestry of 4d. per lamp per hour. To this the vestry have agreed, and we believe the change is to be carried out at once.

THE ELECTRIC LIGHT IN OUR HOMES.—Mr. R. Hammond delivered a lecture on this subject in the Albert Hall, Leeds, last week. He drew attention to the many advantages of the incandescent system, and to illustrate his subject exhibited a model drawing room on the stage of the hall, which was lighted by this means. Mr. Hammond informed his audience that he had adopted this light in his own house in London, and that its cost to him was somewhat less than that of gas, although he laboured under the disadvantage of having to produce his current on his own premises, instead of having it distributed to him from a large station.

ELECTRIC LIGHTING AT THE MERSEY TUNNEL WORKS.—As we have already stated in these columns, the electric

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light has been in use for some time past at the Birkenhead side of the above works. We understand that the contractor, Mr. Waddell, of Edinburgh, is so satisfied with the performance of the lights, that he has had twelve more fitted up on the Liverpool side of the tunnel. The lamps and dynamos are on the Brush system, and have been supplied and erected by the Hammond Electric Light Company of Liverpool, under the superintendence of Mr. James Shaw, district manager, and Mr. Goold, electrician to the company.

M. Marcel Deprez.—We learn that this eminent electrician has had conferred upon him the rank of officer of the Legion of Honour, in consideration of his services to science. His experiments in transmitting power by means of electricity will be fresh in everybody's recollection, and no one will begrudge him the above-mentioned recognition of his untiring energy and zeal. He has succeeded up to a certain point, as readers of this paper know; whether he will be able eventually to make his system entirely successful from a practical and commercial point of view the future alone can show. No doubt it will not be his fault if he does not do so.

Prevention of Fire Risks.—The Society of Telegraph Engineers and of Electricians have just issued their rules and regulations for the prevention of fire risks from electric lighting, in a slightly modified and re-arranged form. The chief rectifications appear to be the omission of the recommendation to fix dynamos on an insulating bed. The committee have also thought well to omit all mention of the best kind of joint for electric light wires, together with the sketch which was given in the old rules, and to content themselves with stating that "joints should be electrically and mechanically perfect, and united by solder." The only other alteration of any consequence that we have noticed is that the maximum electromotive force to be allowed inside buildings, when alternate currents are used, has been raised from 60 to 100 volts.

A Thermoscope.—At the Royal Scottish Society of Arts, a few nights ago, Professor Swan gave a description of his thermoscope. Its construction is as follows:—A small mirror, whose plane is vertical, is carried by a stretched vertical torsion fibre of glass or platinum, and has a short arm projecting from its back. To this arm a fine silver wire is attached by its middle point. The two equal segments of this wire are inclined at an angle approaching to 180 degrees, and are fastened by their ends to a support of some substance, such as glass or platinum, of less dilatibility by heat than silver. By this arrangement even a small change of temperature causes a considerable movement of the extremity of the mirror-arm, consequent rotation of the mirror, and large displacement on a fixed scale of the image of an illuminated wire, formed by rays reflected from the mirror. Temperature indications could thus be read on the scale. The thermoscope was shown in action at the meeting, indicating the fall of temperature inside the receiver of an air-pump when the air was being exhausted; and also the rise of temperature when a light was introduced.

The Commissioners of Sewers.—We understand that the Commissioners of Sewers have requested Mr. Musgrave Heaphy, C.E., to report on the methods of electric lighting for the City. We have no wish to dictate to the City authorities, but we should have thought that such an important body would have called to their aid the best attainable advisers. Mr. Heaphy may be thoroughly competent, but it is difficult to suppose this, inasmuch as his connection with electrical work, and especially with electric lighting, has been of very recent date, and the connection has been from the outside rather than from the inside. It seems to us that the commissioners might have found a trained electrical engineer to advise, and then, instead of having to obtain a further report, as they will probably have to do under the present conditions, their advice would have been thorough in the first case. Why put aside such men as Professor Ayrton, Professor Forbes, Professor Garnett, Professor Lodge, Latimer Clark, Dr. Muirhead, and other well-known men whose lives have been devoted to the study of electrical matters, and whose opinions are really valuable, for gentlemen whose knowledge of electrical work is so recent. There is one question we should like to ask. Is rumour correct in stating that a gentleman standing in the front rank of those connected with electrical matters has declined to act as *collaborateur* with Mr. Heaphy?

The Crystal Palace Electric Exhibition.—On Wednesday evening the diplomas and medals gained by the exhibitors at the Crystal Palace Exhibition of 1882 were presented to the recipients by the Duke of Teck. The awards included ten diplomas of honour granted to those who did not exhibit from trade motives. These were bestowed upon the Postmaster-General, the Secretary for War, the Anglo-American Telegraph Company, the Eastern Telegraph Company, the Telegraph Construction and Maintenance Company, the Submarine Telegraph Company, the South-Eastern Railway, the London Brighton, and the South Coast Railway for the general excellence of their exhibits, Mr. C. F. Varley for his induction machine and condensers, and Mr. R. H. Froude for a dynamometer. In addition to the diplomas the awards consisted of twenty-nine gold, twenty-seven silver, and thirty-five bronze medals. A detailed list of the recipients of these was published in our issue of the 5th August, 1882 (*The Electrician*, Vol. IX., p. 271). Before presenting the awards the Duke made a short speech, in which he showed himself to be familar with his subject. He alluded to electricity as being "for centuries the philosopher's toy," until Volta, Oersted, and Faraday revealed to us its true nature. In connection with the laws governing the action of this mysterious power, he paid tribute to the names of Ohm, Gauss, Weber, Joule, Clerk Maxwell, Sir William Thomson, and others. Speaking of the telegraph and electric light, his Serene Highness quoted a string of names, from Ronalds to Hughes, and Pixii to Edison and Swan, as if they were old friends, as they are to most of us. The Duke was afterwards entertained at a dinner in the Palace, at which many electricians were present.

M. Deprez's Experiments.—After the excellent reports made to the Academy of Sciences in Paris by M. Tresca and his *confrères* on the experiments made by M. Marcel Deprez at the Northern (of France) Railway Company's workshops in February last, we should have thought it impossible for incorrect ideas to exist on the matter. We regret to find, however, that the Paris correspondent of the *Daily News* has still some very hazy notions of what actually was accomplished by M. Deprez during his experiments. This would not matter so much if the correspondent in question would keep his notions to himself. Unfortunately he does not, but spreads them abroad before an innocent public, with the natural result that the latter are deluded by them. In the first place, the *Daily News* correspondent says that the wire in the circuit was 20 kilometers long, that is, it was taken to a village 10 kilometers from Paris, and brought back again. Now, 20 kilometres = about 21,860 yards. Turning to M. Tresca's report, as given in *The Electrician* for March 31 and April 7, we find it there stated that the circuit wire

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was 17,000 metres, about 18,133 yards long. Then, again, our contemporary's correspondent says:—"The first (dynamo) gave out a 9 horse-power force, and the second (dynamo) rendered half that quantity. The loss of power in transmission is 50 per cent.," &c. What does M. Tresca's report say as to this? "Considering the average of the first six experiments," viz., on the 11th February, "we see," he says, "that 2·03 horse-power was transmitted with an expenditure of 6·21 horse-power at the shaft of the dynamometer, which corresponds to a return of ·327 horse-power." Again: "Summing up, it may be stated that the power actually transmitted to a distance of 8·5 kilometres (about 5·28 miles) over an ordinary telegraph wire of 4 millimetres diameter, according to M. Deprez's method of connecting up the machines, represents a third of the motive power." Now let us turn to his report on the second series of experiments, which took place on the 18th of February, at the same place and on the same circuit. From the tables there given we find that the power actually transmitted was ·318 horse-power, in connection with which figures the report says:—"The attention of makers should be given to these figures, and efforts made to minimise the losses so as to approach an efficiency of 50 per cent." The *Daily News* correspondent evidently delights in dealing with round numbers, but surely he might be a little more accurate.

Another Electrical Exhibition.—We have received an official notice intimating that the Italian General Exhibition will be held in Turin, from April to October, 1884, and that a special section is to be allotted to electricity, to which foreigners are invited to contribute. The exhibits will be classed under the following heads: Statical electricity. Electro chemistry and materials for the apparatus and for electric circuits; batteries, accumulators (storage of electricity), &c., wires, cables, &c., lightning conductors. Apparatus for the study of the electric current. Measuring instruments; apparatus for didactic demonstrations. Application of electricity to the transmission of signals and analogous applications. Indicators at a distance, chronographs, electric meters, electric clocks. Telegraphs, telephones, microphones. Application of electricity to safety on railways; signals, block-systems, &c. Application to the firing of mines, and analogous applications. Application to medicine and surgery. Industrial production of electric currents; magneto-electric machines and dynamo-electric machines. Electric lighting. Transport to a distance and distribution of mechanical energy by means of electricity. Electro-metallurgy and galvanoplastics. Various applications. All applications for space are to be sent in on a special form, and must be in the hands of the executive committee by the 31st August, 1883. Motive power will be supplied gratuitously for the lighting and for the experiments to be made in the galleries and in the gardens by the committee itself. In this case the installation or placing of the conductors also will be provided for, gratuitously. In any other case the motive power will be supplied at a price varying from 30 centimes to 50 centimes an hour and per horse-power, according to the number of hours of work and according to the amount of power required. The transport and installation or placing of the machines and of the apparatus will be executed at the expense of the exhibitors. The committee will take the necessary steps in order to obtain from the railway companies reductions in the rate of prices for the articles destined for the exhibition, which articles, however, must always be forwarded carriage paid.

Telephonic Communication in Leeds.—It is about three years since the telephone was introduced into Leeds. For some time but little progress was made in inducing the merchants to take to the use of the new invention. Gradually, however, it began to be known, and as a consequence used, and the progress made during the past twelve months has been very satisfactory. The "calls" at the National Telephone Company's Exchange, Commercial-buildings, Leeds, for the week ending April 13, 1883, were 3,812, with a total of exchange subscribers of 150, against only 632 "calls" and 90 subscribers for the corresponding period of 1882, or an increase during the past year of 60 Exchange subscribers and 3,180 calls. The Corporation of Leeds was one of the first corporate powers to introduce the system of telegraph communication between the various police stations and the Town Hall. The Watch Committee of the same corporate body have decided to establish telephone communication between the Town Hall and the whole of the police stations in the town instead of the A B C telegraph system now in use. At a recent meeting the Watch Committee accepted the tender of the National Telephone Company, Limited, to connect all the police stations in the town for the sum of £211 per annum, the amount paid to the Post Office for the telegraph system, being, we believe, £215 per annum. The contract includes a connection between the Town Hall and the Telephone Exchange, by which arrangement subscribers to the Exchange urgently requiring the services of the police or fire brigade may communicate directly with head-quarters. Three months' notice will be given to the Post Office authorities to terminate the agreement now in force, and by the end of that time all the telephone lines and instruments will be connected and in working order. The above facts show the increasing demand for, and the opinion the professional and mercantile community have of the utility and, in fact, necessity of telephonic communication in this important centre. The work of connecting the police stations, as also the other works in progress, is now being carried out under the superintendence of the courteous and able local manager and engineer of the National Telephone Company, Mr. W. L. Bishop.

The Devon and Cornwall Electric Light Company.—The hearing of the petition for the winding up this company, presented on the 1st November last by Mr. H. Wherlow, a shareholder, was heard before Mr. Justice Chitty on Tuesday. It appeared that shortly after the presentation of this petition nine actions were brought by shareholders for the rescission of their contracts to take shares in the company, on the ground that they had been induced to subscribe for the same by reason of statements in the company's prospectus falsly representing that the company had the exclusive right of using in the districts therein named the Lane-Fox patents. On the 21st of December last Mr. Cadogan, one of the plaintiffs in the actions referred to, obtained an order on motion for the removal of his name as a shareholder from the company's register, and for the return of the money paid by him in respect of his shares, but the order was stayed pending the hearing of the present petition. The allegations upon which the petition was based were that the concessions granted to the company had been discovered to be not so wide as had been anticipated, that the mis-statements in the prospectus had caused proceedings to be taken by the shareholders, that the company had practically never carried on business and could not carry on business successfully, and that for these reasons, and having regard to the fact that by reason of the claims of the shareholders for the return of their money the assets of the company (including any uncalled capital) were insufficient for its purposes, it was just and

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equitable that the company should be wound up. Since the date of the presentation of the winding-up petition, and of the successful motion, the actions against the company by its shareholders had increased to 35 or 37, and the plaintiffs, including Mr. Cadogan, strenuously opposed the winding up of the company on the ground that the statutory effect of the winding-up order would be to place them in the same position as the contributories who had brought no actions, and who had not been deceived by or had acquiesced in the prospectus; while if the petition were dismissed Mr. Cadogan, who had made out his case, and any other of the plaintiffs who should succeed in making out their cases, would rank as creditors against the company for the value of their shares. The petition was unanimously supported by all the shareholders other than those who had brought actions against the company.—Mr. Justice Chitty said that the truth of the allegations in the petition had been made out by the petitioner. As regards the actions brought by Mr. Cadogan and others Mr. Justice Chitty said that although the misrepresentations in the prospectus amounted in law to a fraud by the company, yet in fact the company was not their author, the true author being the hand who drew the prospectus. It was therefore legitimate for the company to say that so far as the company consisted of individual shareholders it was innocent, and that the proper way of meeting the case of all parties was to obtain a winding-up order. His lordship was satisfied that the petition had not been collusively presented. He therefore made an order for the compulsory winding up of the company, with usual costs.

The Vienna Exhibition.—Since our last note on the applications for space at this exhibition we have received information from the organising committee, giving the names of numerous other intending exhibitors. S. Schuckert, of Nürnberg, will show his dynamos and a rock-drill actuated by electricity; Hermann Sedlaczek lamps, dynanometers, &c.; Alexander Kovaco, of St. Petersburgh, will exhibit electro-plating in all its branches; C. R. E. Menges, of Hague, dynamo machines, measuring instruments, electric lamps and clocks, &c. This exhibit will also include the transmission of power by means of electricity, when it is said that Mr. Menges will show several novelties in the construction of dynamos for this purpose. Paul Rebikoff, of Moscow, has promised to show a new dynamo for feeding differential lamps, also measuring instruments, telephones, &c. A. Bornhardt, of Brunswick, will be represented by blasting apparatus in which the electric current is utilised. Professor Fleeming Jenkin, of Edinburgh, intends to exhibit his system of telpherage, for which he has recently taken out a patent; while Professors Ayrton and Perry will show a model of their electric railway. Messrs. J. Coxeter and Son will have a miscellaneous exhibit of telephones and other electrical apparatus. Amongst the French exhibitors will be found the Société Gramme, the Compagnié Pour L'Eclairage Electrique, Jablochkoff system, and the Compagnié Electrique. F. O. R. Götze, of Leipzig, will exhibit vacuum tubes (Crookes's), an apparatus of De La Rive's for showing the rotation of electric light around a magnet, and a phosphoric apparatus of Dr. Puluj's, a Viennese electrician. The Duplex Electric Light Company, of London, are to show their batteries, which have recently been made public here. Messrs. Felten and Guilleaume, of Mülheim-on-Rhine, will be well represented in their own particular department of cables and wires of all classes. The India Rubber, Gutta Percha, and Telegraph Works Company, of London, and Persan-Beaumont, France, will also exhibit. Amongst the other names we notice those of G. B. Pirelli and Co., of Milan, T. O. Monchel, of Paris, W. Bauer, of Paris, G. Montefiore Levi, of Anderlecht, near Brussels, the Telegraph Construction and Maintenance Company, Walter T. Glover and Co., of Manchester, and the Electrical Power Storage Company, of London. This latter company have promised to send a number of their accumulators—the Faure-Sellon-Volckmar—to the exhibition, and also a boat driven by current supplied by these accumulators, which is to ply regularly on the Danube during the course of the exhibition. From still later information than the above we learn that the German Government have consented to exhibit, and that preparations to this end have already been begun in the various departments of that empire, which deal with the many applications of electricity. Also that the north-east gallery of the Rotunda, where the exhibition is to be held, will be fitted up as a suite of rooms on the furnishing and decoration of which all the art and skill of Viennese cabinet makers will be expended. The rooms will be lighted by incandescent lamps with the special object of showing the adaptability of this system to decorative lighting for interiors.

Luminosity of the Magnetic Field.—Professor W. F. Barrett, of Dublin, has been making some interesting experiments to test the correctness of the discovery claimed to have been made by the late Baron von Reichenbach, viz., that a peculiar luminous effect, resembling a faint electric discharge in rarefied air, emanated from the poles of a magnet, and was rendered visible in a perfectly darkened room. Several scientific men have taken up the subject from time to time, but the only result of their labours has been to throw discredit on Reichenbach's statement. Professor Barrett is, however, of the opinion that the evidence adduced by the Baron is too weighty to be readily explained away, and resolved to make some experiments of his own to try and throw some additional light on the subject. The experiments were undertaken by a committee of the recently formed Society for Psychical Research, of which Professor Barrett formed one, and were carried out a few weeks ago at No. 14, Dean's-yard, Westminster, London, S.W. The following detailed account of what took place is abridged from a note to the *Philosophical Magazine*, communicated by Professor Barrett. He says:—One of these rooms was so arranged that it could at pleasure be made into a perfectly dark chamber, no glimmer of light being perceived even after an hour's immersion in the darkness. A powerful electro-magnet was mounted on a heavy wooden stand, and stood by itself in the centre of the room; wires led from the magnet to a commutator in another room, and thence to a large Smee battery outside. Three observers (Professor Barrett names them) were in charge of the commutator, making and breaking the current at their own pleasure, and noting down the exclamations made by the observers in the adjoining darkened room, the voice being easily heard through the intervening curtains. In the dark chamber were three other observers with Professor Barrett, together with two persons who, in a preliminary trial a day or two before, had declared they saw a luminous glare over the poles of a permanent steel magnet. These were Mr. G. A. Smith and a boy, Fred. Wells, who is an assistant in a baker's shop; both of them were entire strangers to these experiments up to the time of the preliminary trials, and disclaimed any knowledge of Reichenbach's work. For some time after entering the dark chamber nothing was seen, though during this time the electro-magnet was frequently excited. After about half an hour had elapsed, Wells, and subsequently Mr. Smith, declared they saw a faintly visible smoke in the room; being

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asked where, each in turn led the Professor up to the magnetic poles as the seat of the luminosity. One pole (the north seeking pole) they said was brighter than the other. The luminosity was described as like two waving cones of light, with the apex of each cone on the magnetic poles; the breath was able to deflect but not to extinguish the glow. (In a footnote Professor Barrett likens this glow to the long ascending stream of faintly lambent aqueous vapour seen far above the flame of pure hydrogen in a well darkened room.) It was not intercepted, they said, by a black velvet cloth, nor by a deal board laid flat over the poles, but they declared it was at once obscured when these bodies were held between the eyes of the observers and the magnet, the absolute darkness being, of course, preserved continuously. When the current was cut off, both the observers simultaneously exclaimed that the light had disappeared. The current was afterwards made and broken at irregular intervals, unknown to the observers; in every case except one the latter noticed the appearance and disappearance of the glow. Professor Barrett proceeds to explain subsequent experiments that were made, all of which were successful. For ourselves, we may say that we have made similar experiments, but have only obtained negative results, whilst friends of ours have had no better fortune. However, Professor Barrett seems to have succeeded so far, and will no doubt prosecute his researches still further, for the success of which he has our best wishes.

Electric Lighting and the Board of Trade.—On Saturday last a deputation representing electric lighting companies waited upon Mr. Chamberlain at the Board of Trade. The deputation consisted of Mr. Bouverie, Mr. Arnold White, and Mr. Waterhouse representing the Edison Company; Mr. Crompton, Mr. Swan, and Mr. Morris, jun., on behalf of the Incandescent Company, and Mr. Moulton accompanied the deputation. We take the following account of the proceedings from *The Observer* of Sunday last:—"Mr. E. P. Bouverie stated the case for the deputation, and after some remarks from Mr. Moulton, Mr. Arnold White, and Mr. Crompton, Mr. Chamberlain said in reply that he regretted the tone of Mr. Bouverie's remarks. He seemed to speak with a high sense of conscious virtue, and to criticise matters which were really beside the actual circumstances of the case. He entirely concurred that it was the duty of the Department to facilitate the development of lighting by means of electricity, and much had been done by the Department to smooth away obstacles to the operations of the companies by putting them in agreement with the local authorities, and saving expense in application to Parliament. In doing this they had been to a large extent successful. Negotiations had been going on in the most friendly spirit for two months, and he was sure he would be borne out by Mr. Moulton when he said the Department had been most anxious to remove any difficulties in the way, to abandon any unreasonable claims, and to remove any obstacles of which the companies complained. But while the Board must do everything to facilitate this experiment, they were also entrusted by Parliament to protect the interests of the public, and it was not the interest of the public or of the *bonâ fide* companies that bogus companies should be established for the purpose of obtaining a *quasi* monopoly, which there was at one time great fear would be the case, for there had been applications which, if granted, would have placed the control of the further development of the system in the hands of the people who had no knowledge, no ability, and no means, and who were simply speculators with other people's money. The Board, therefore, wished to devise some means by which they might separate the bogus from the *bonâ fide* companies. They had not at present seen their way to any other means of doing this but by insisting upon some deposit of money. He would be glad if he could see his way to meet any objection which might be raised; but he would say that those conditions which seemed unreasonable to Mr. Bouverie had been accepted willingly by other companies, notably at Birmingham. What were these terms which were considered unreasonable by Mr. Bouverie? The Board had made a rule that one-half of the amount which was required to make the street works in the first schedule should be deposited, whatever proportion to the capital that might bear, but he doubted whether it would amount to more than one-sixth of the total sum which would be invested in any of these undertakings. Mr. Bouverie had said that there were no arrangements for the repayment of these sums, but in that he was mistaken, as it was distinctly provided for in the Act, and if that were not clearly expressed it might be made so after conference between the parties. He said so much as to the actual proposal, but if they could get the consent of the local authority in any case to the reduction of the amount proper, the Board of Trade would not think it at all necessary to stand out in opposition to such an agreement. But he had considerable doubt whether the terms offered of 8 per cent. by the Vestry of St. George's, Hanover-square, would be more advantageous to the company than the terms proposed by the Board, for in the former case the money was locked up until the completion of the work, whereas by the latter arrangement the money could be withdrawn in sums of not less than £1,000 during the progress of operations. A question had arisen with regard to insolvency, and it had been pointed out that the clause was almost taken *verbatim et literatim* from the Tramway Act, which had been to a considerable extent the basis upon which legislation had gone in this matter. There was also the question of transfer, which had been touched upon. Mr. Bouverie complained that the Act stipulated that no transfer of an undertaking should take place without the consent of the Board of Trade, but there had been a clear indication of the mind of Parliament that the Department were to look into every case in which transfer was proposed, and consider if there were good and sufficient reasons for objecting to it, in which case only would the Board interfere. If no good and sufficient reasons were urged against the transfer the Board would not consider it their duty to withhold their consent. As to the appointment of inspectors, there again the Board were under statutory obligations, and they had no power or funds to make appointments; but, even if they had, he did not like the notion of centralisation, of which they had already too much. A question had been raised as to the penalty of revocation which was imposed for a breach of the order. It had been urged that this was an extreme penalty, but he knew of no other expedient which would as readily ensure the compliance with the terms of the order, and it was well that the Board should be able to hold such a power over the head of the company *in terrorem* in order to secure the adequate fulfilment of the contract under which they came. In conclusion, they might say that the order in its present form had been accepted and acted upon by several companies already established. With regard to any particular case which might hereafter be brought before him, he would be glad to consider circumstances which would justify the alteration of the general scheme, for, of course, he did not say that the order which was made was to meet all the varied circumstances which might from time to time arise."

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SOME ELECTROSTATIC AND MAGNETIC RELATIONS.

BY OLIVER HEAVISIDE.

(CONTINUED FROM PAGE 511.)

6. We may see from the surface integral in (4) what to do in the case of a purely surface distribution of electricity, *i.e.*, a finite quantity of electricity upon a surface with no thickness in the layer. For, substitute for the surface charge a volume charge by endowing the layer with a small uniform thickness, t, so that if σ be the surface density, we shall have $\sigma = \rho t$. The surface-integral in (4) with the corresponding ones for Y and Z tell us that we must draw a vector of length ρ normally to the surface of the layer outward on both sides, one such vector for every unit of surface, ρ having the proper value for the portion considered. This constitutes a normal system of vectors. The volume-integral tells us that we must draw a vector tangential to the surface of length $-\nabla\rho$, one for each unit of volume of the layer, and hence we may substitute one of length $-t\nabla\rho$ for each unit of surface. The vector-potential of these two systems of vectors will be the electrostatic force at any point.

Now let Q be a point where R is required, and let its distance from a point S on the real electrified surface be r, and its distances from the corresponding points S_1 and S_2 of the outer and inner surfaces of the electric layer be r_1 and r_2, the outer surface being that next Q. Here S_2, S, and S_1 lie along the normal to the surface through S. Then, for the unit of surface surrounding S, we have the normal vectors contributing $\left(\frac{\rho}{r_1} - \frac{\rho}{r_2}\right)$ to the value of R at Q. Now let the thickness of the layer decrease indefinitely, so that S_2 and S_1 approach S; then, since $r_2 = r_1 + t\cos\epsilon$, where ϵ is the angle between r and the normal n outward, this expression becomes

$$\rho\frac{r_2 - r_1}{r_1 r_2} = \rho\frac{t\cos\epsilon}{r^2} = \frac{\sigma}{r^2}\cos\epsilon = \sigma\frac{dr^{-1}}{dn}.$$

Also, for the tangential vector, we have for the part of R contributed by the unit of surface surrounding S,

$$\frac{1}{r}(-\nabla\rho)\,t = -\frac{t}{r}\nabla\rho = -\frac{1}{r}\nabla\sigma.$$

Therefore, divide the electrified surface into unit areas. On each unit area erect a single vector of length $\frac{\sigma}{r^2}\cos\epsilon$ in the direction of the normal, and draw another of length $\frac{1}{r}\nabla\sigma$ tangential to the surface in the direction in which the surface density σ decreases fastest. The resultant of the two systems of vectors will be the electrostatic force at Q.

If the surface density be constant, we have only the normal vectors to deal with, and it might appear that the force due to an electrified *plane* surface with σ constant were always parallel to the normal, which we know to be not true, unless the surface be infinitely extended. In fact, the preceding construction applies only to a closed surface, without a bounding edge, that is to say, or to cases of unclosed surfaces in which the density decreases gradually to zero, either at the edge or before reaching the edge. We may imagine the electricity to terminate suddenly at a certain boundary. If so, we see, by first endowing the layer with thickness, that we have, in the above, neglected the edge, where we should, from every unit of area of the strip forming the edge, draw a vector of length ρ normally outward. Now, when we decrease the thickness of the layer indefinitely, the edge vectors are ultimately to be thus defined. Divide the edge (now a closed curve) into unit lengths, and from each unit length draw a vector of length $\frac{\sigma}{r}$, whose direction is perpendicular to the edge and also to the normal to the surface at its edge. It is now the resultant of the three systems, the normal, the tangential, and the edge vectors which gives the force at Q. Thus

$$\mathrm{R} = \mathrm{v.}\,\Sigma\left(\sigma\frac{dr^{-1}}{dn}\right) + \mathrm{v.}\,\Sigma\left(\frac{-\nabla\sigma}{r}\right) + \mathrm{v.}\,\Sigma\frac{\sigma}{r}. \quad . \quad . \quad (5)$$

where the first two summations are extended over the surface, and the third round its bounding edge, $\sigma\frac{dr^{-1}}{dn}$ being normal, $\frac{-\nabla\sigma}{r}$ tangential, and $\frac{\sigma}{r}$ perpendicular to the normal to the surface, and to the tangent to the edge.

Now, we also know that $\mathrm{R} = \mathrm{v.}\,\Sigma\frac{\sigma}{r^2}$ extending summation over the surface, the vectors being now drawn in the direction of r. This we may decompose into normal and tangential summations, viz.:—

$$\mathrm{v.}\,\Sigma\frac{\sigma}{r^2}(\|r) = \mathrm{v.}\,\Sigma\frac{\sigma}{r^2}\cos\epsilon\,(\|n) + \mathrm{v.}\,\Sigma\frac{\sigma}{r^2}\sin\epsilon\,(\text{tangential}).$$

Comparing which with (5), their right hand members being equal, and the first terms of the same identical, we see that

$$\mathrm{v.}\,\Sigma\frac{\sigma}{r} = \mathrm{v.}\,\Sigma\frac{\nabla\sigma}{r} + \mathrm{v.}\,\Sigma\frac{\sigma}{r^2}\sin\epsilon. \quad . \quad . \quad . \quad . \quad (6)$$

the edge summation thus being expressed in terms of surface summations of two tangential vectors, the first in the direction of greatest increase of σ, the second in the plane of r and n.

The proof of this theorem in Cartesian co-ordinates, x, y, z, is rather complex, but we may see its truth by means of Ampere's "dodge" of substituting a network of linear currents over a surface for a current round the edge. See Theorem II., p. 56, and observe that, although there the line integral is of the resolved part of a vector in the direction of the curve, and that when we substitute for it the sum of a number of other line-integrals, it being allowable to do so because the direction of rotation round the closed curves is the same for all, so that all the interior line-integrals cancel, and nothing is left but the integral round the bounding edge, yet the same method would apply exactly if the line-integral were of a vector drawn perpendicular to the edge in the plane of the surface; for if we join two points of the original closed curve by a line, thus making two circuits with a portion in common, and draw the vectors perpendicular to the curves in the plane of the surface for both circuits, outwards in each case, the vectors for the common portion are oppositely directed and of equal magnitude, and therefore annul. We see, therefore, that the edge summation $\mathrm{v.}\,\Sigma\frac{\sigma}{r}$ can be expressed by a surface summation, and that the portion of this summation for the unit of surface is nothing more than the value of $\mathrm{v.}\,\Sigma\frac{\sigma}{r}$ taken round its bounding line. We require then to know the resultant all round the line bounding the unit area enclosing any point S, of the vector of length $\frac{\sigma}{r}$ drawn perpendicular to the bounding line. Its value will depend on the tangential variation of σ in different directions from S radially, and upon the variation of $\frac{1}{r}$ about S. The first is $\frac{\nabla\sigma}{r}$, the latter $\frac{\sigma}{r^2}\sin\epsilon$, and these are the vectors that appear in equation (6), whose truth is, therefore, verified. [Vector integrals are sometimes very troublesome to manage. The above example shows the great aid to be derived from looking at the vector itself, rather than working with its components, introducing long and complex formulæ.]

If we imagine a plane surface electrified with constant density, it might be the surface of a dielectric for example, the normal vectors give a force parallel to the normal, and the edge vectors a force parallel to the plane of the surface; their resultant is the actual force. The component parallel to the plane is, of course, of great importance near the edge, making the lines of force curve outwards.

The method by which we passed from the two vectors for volume density to one normal vector for surface density and the calculation of their potential, may be compared with the process of finding the magnetic potential of a normally magnetised shell. The only difference is that we are here concerned with vectors instead of scalars. In the case of the shell we have + magnetism in one side, — in the other, of

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finite amounts when the thickness is finite, and we find their combined potential at any point. Then decrease the thickness of the shell indefinitely, and increase the surface density of magnetism correspondingly, so that the magnetic moment remains constant, and find the limit to which the potential approaches. It is $\frac{\sigma}{r^2}\cos\epsilon$ per unit area. In the above, the process is the same, but the quantity operated on is a vector drawn parallel to the normal instead of a scalar. The method is also analogous to that which may be employed (p. 33 *ante*) for finding the magnetic force due to a current sheet by means of the vector-potential of the curl of the current, except that the oppositely directed vectors are tangential in that case, and the single vector is normal.

7. We may leave, however, the interpretation of the special forms which results assume for surface distributions, as it is so much easier to work with volume densities. The relations stated in sections (4) and (5) will become clearer, and a more comprehensive view of the matter will be obtained if we make the force $= \frac{e}{4\pi r^2}$ at distance r from a charge e, which is equivalent to defining the electrostatic potential $P = \Sigma\frac{\rho}{4\pi r}$.

Let P_1, R_1, P_2, R_2, P_3, R_3, P_4, . . . be quantities thus arranged. Starting with, say, P_4, let it be an arbitrary scalar; it may be volume density of electricity. Let P_3 be its potential, P_2 that of P_3, and P_1 that of P_2. The P's are therefore all scalars, and differ two degrees consecutively in length dimensions. Now between them insert R_1, R_2, R_3, . . . such that R_1 is the space variation of P_1, R_2 of P_2, and so on. Thus, the R's are all vectors, and of intermediate degrees in length dimensions.

It follows from this specification, first, that any R is the *vector*-potential of the next following R; thus, $R_1 = v.\Sigma\frac{R_2}{4\pi r}$, &c.; and, secondly, that any P is the divergence of the preceding R; and there is uniformity throughout. There is no need of additional proofs, as we have already gone through the process for two auxiliary R's, viz., R_1 below ρ and R_0 above P, in sections 5 and 4 respectively. Two consecutive P's may stand for electrostatic potential and for volume density, the intermediate R then representing the corresponding electrostatic force.

8. But we may, and with some advantage, transfer ideas from electrostatic force to the magnetic force of permanent magnets, taking the limited view of the magnetic force that it is due to magnetic "matter," as in Art. IV. "Current Energy," p. 439 *ante*. That is, we replace electricity by magnetism, electrostatic force by magnetic force, and electrostatic potential by magnetic potential; and we shall employ the definition of potential as in the last paragraph. The relations are exactly the same mathematically.

Now, besides the force due to magnetism, let there be also ordinary electric currents, and consider the resultant field, which is due to the superposition of a field consisting of closed tubes (due to current) and of another of unclosed tubes (due to magnetism). Let B be the actual magnetic force, and separate it (as done p. 439 *ante*) into B_1 and B_2, of which B_1 has no convergence, and B_2 no curl; the latter corresponding to the R's of the last paragraph. Let C_1 be the curl of B_1; it is the current density; let C_2 be the divergence of B_2; it is the density of magnetism; let A_1 be the vector-potential of C_1, and A_2 the scalar-potential of C_2. And to exhibit the relations more fully, introduce D below C, and Z above A, both vectors. Z_1 the vector-potential of B_1, Z_2 that of B_2; D_1 the curl of C_1, and D_2 the divergence of C_2.

Z	A	B	C	D
$Z_1 + Z_2$	$A_1 + A_2$	$B_1 + B_2$	$C_1 + C_2$	$D_1 + D_2$
v. v.	v. s.	v. v.	v. s.	v. v.

The quantities with the suffix 1 refer to the current system, with 2 to the magnetism. The letters v. and s. are placed to show whether they are scalar or vector. We know that Z_1, A_1, B_1, C_1, D_1 are related uniformly thus: $A_1 =$ curl Z_1, $B_1 =$ curl A_1, &c.; and also thus: $Z_1 =$ v. potential B_1, $A_1 =$ v. potential C_1, &c. Also, in the other series, $Z_2 =$ v. potential B_2, and $A_2 =$ s. potential C_2 and $B_2 =$ v. potential D_2; alternately scalar and vector; whilst a scalar in the series is derived from the preceding vector by the operation divergence, and a vector from the preceding scalar by the operation of space variation.

Observe that we may compound B_1 and B_2 and obtain B the real magnetic force. Also we may compound D_1 and D_2, since they are both vectors, forming a new vector, D; and likewise Z_1 and Z_2 (both vectors), forming a new vector, Z. And here Z, B, and D are vectors which have both curl and convergence. Also, Z is clearly the vector-potential of B, and B the vector-potential of D; because this is true of their constituents, which are in each case homogeneous—of the same nature, that is to say. But the intermediate A's and C's do not apparently admit of being combined. A_1 is truly the potential (vector) of C_1, and A_2 the potential (scalar) of C_2; but A_1 and A_2 are not homogeneous, nor are C_1 and C_2.

(TO BE CONTINUED.)

A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XXI.

The employment of the two double current reversing keys in the last number seems to call for a short consideration of their practical use, and we give, accordingly, a figure, by the aid of which we desire to illustrate the action taking place in the alternate charges with positive and negative currents. The electrometer key only is drawn here, as, of course, but one current at a time passes to line, and the reader knows that both battery and electrometer keys are similarly handled. The two positions in the figure are to represent the action of the two different charges from the battery; when positive is to line the result appears as on the right hand, and as on the left when a negative charge passes. Taking the latter

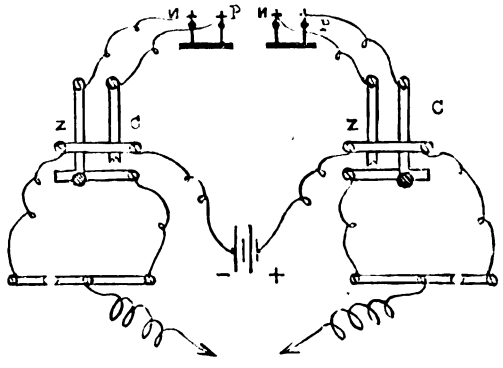

FIG. 44.—Cable Circuit, Electrometer Reversals.

charge first, on closing the circuit, the plug being in its place, the cable and both pairs of quadrants are all negatively charged, but on removing the plug (and following the plan) it is seen that a negative charge coming in from the battery, at Z, it thereby connects the pair of quadrants joined on that side to the lower bar, and this charge can now only pass by the other side C, which is in contact with the upper bar, where the charge enters; the cable is cut off from that or the C side, and so also is the pair of quadrants N in connection with it, both leaking together, and the battery connects with P. Now take the other side. C is clamped down, and the plug is in its place. The charge now as before passes to cable and all quadrants, but on lifting the plug the cable is left connected with P, the opposite pair of quadrants to that previously charged, and the bar remains in connection with the other pair N. We have been able to illustrate the alternate separation of the key pieces from the lower bar, but cannot very well show the cutting off from the upper bar, so the reader must remember that the depression of a key piece severs the connection on

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that side between the upper and lower bars. The object obtained by these two double current keys might also have been effected by means of a plug commutator, a four-way piece; an example of its use appears in several figures. We have not at present any fresh test to suggest, but shall now present two modes of taking what are called final tests. They are for insulation resistance, and on the principle of that first explained, in which this quality is measured by deflection whilst the battery charge is continuous. When any section of cable is completed it is customary to take special insulation tests for periods of from thirty minutes to an hour. The length of time generally depends on the length of section, over thirty knots being one that requires the longer of the two operations. One of these will be taken shortly after completion of the section, and another when the same length is to be shipped. In both cases the cable is well under water, the end also being generally sealed—that is, completely covered with gutta percha, so as to be protected from the air. Of two ways of making these tests, in both of which positive and negative currents are employed, one consists in applying the currents alternately for half an hour, reversing every minute; in the other one current is used for thirty or sixty minutes, a reading being taken every minute or half minute, and after an interval of two or three hours, during which the cable is put to earth to free it entirely of its charge, the same operation is performed with the opposite current. Of the two methods the first is the more severe, as reversals whilst two or three hundred cells are being employed will prove more searching than one current continuously applied. The tests, however, are taken with the assumption that the cable is perfect, and the latter of the two is preferable in the fact that it furnishes data for pronouncing on the goodness of the section. We will commence with the forms of two, calling it a "half-hour minute reversal test."

The operator must first assure himself that the cable is properly under water, and the further end sealed, or, if not sealed, well insulated and carefully protected against any interference. As regards the choice of current to commence with, some prefer *negative*, and others *positive*. Let us commence with the former. In the case of a good, that is a perfect cable, the point is of much less importance than if a fault were present. We suppose the galvanometer scale to be of the ordinary length and type, with zero at the centre, and the shunt must be chosen with a view to the production of a deflection as large as possible, and as the readings are all to be taken after one minute's charge, the operator will arrange the circuit so that the spot may be as near as may be convenient to the end of the scale when the minute expires, convenience referring to the desirability of watching the progress of the deflection during the interval. As we have in an early number fully explained the course of the ordinary galvanometer insulation test, there is but little detail to be considered; a general direction to be very careful and exact is, however, imperative. A learner, as such, would never be directed to take a final test; but there must be a first time, and to any one thus commencing we particularly address our cautions. One point is specially worth noting. It will be seen at once that, as the readings are taken once every minute and each successive deflection is the result of an opposite charge to that of the preceding one, some portion of time, however limited, must be occupied in the act of reversal. If, for example, the negative charge were applied at, say, eleven o'clock exactly, and the deflection read at eleven hours one minute, on then reversing, however quickly, the positive charge would not have endured sixty seconds when its reading was taken at eleven hours two minutes; at the very least two or three seconds must have been spent in reversing the battery key and commutator, especially as the galvanometer must be short circuited between the two charges. The course to be followed then will be to charge, say, with zinc at a full minute, as at eleven, the short circuit plug being of course in its place; this will be removed after fifteen or twenty seconds, and the spot as arranged according to the suggestion above will appear at the end of scale, say at thirty seconds. This will be watched till close on the end of the minute, that is two or three seconds before it expires, when the short circuit plug must be promptly inserted and the key reversed; of course the charging side must be released first and the other side instantly put down. The readings on a scale of the ordinary type will be really that of the fifty-eighth second, but where the divisions are so small the result is sufficiently correct. The reversal must be so timed as to cause the charge to act at the exact minute. It is impossible to have exactly a sixty seconds' reading unless we should commence each succeeding minute a second or two later. The operator must be wary and collected. The positive and negative readings may either be taken on different sides of zero, or by reversing the commutator plugs both may be read off on one side. It is better, however, not to shift the plug, for a reason given in a former number, and also to prevent even the minute loss of time occupied in the change. The deflection will in the case of a perfect cable be the same, or nearly so, for both currents. The cable should be entirely free of charge before commencing, or as nearly as it can ever be; at the end of the test it must be put to earth again, and so remain.

As regards the test for 30 minutes each with alternate currents there is nothing to be added to our instructions for the ordinary test. The cable is first tested with one current for the time fixed, readings being taken every minute, and, after being put to earth for an hour or two, the other current is similarly observed. It is not customary to read at less intervals than one minute when using the ordinary sized scale, but an arrangement is in use at certain establishments by which a deflection may be obtained at every 30th second. Moreover, there are features in this test which render it the best and most conclusive of all final tests. It consists of a long and wide scale, graduated like the smaller one, but whose divisions are at least $\frac{1}{8}$in. apart. A covered lamp is provided with a tube and sliding lens for adjusting the focus, and a fine wire is stretched perpendicularly across the end, dividing the light into two hemispherical portions. The lamp is slightly tilted, and is so placed with relation to the galvanometer that the rays of light slope upward to the mirror, and are thence again reflected upwards to the scale, which is fixed on a wall behind the lamp. The focus is adjusted so that the light falls on the scale, and is there represented by a glowing circle varying in size according to the adjustment, and perpendicularly divided by a fine black line, which latter clearly marks each division and half-division as it passes on. The divisions are all counted as whole numbers, but when the spot travels slowly the fine centre line stands easily between any two divisions, and at this point the reading is counted as a half-division. This is decidedly the best of all arrangements for taking a long insulation test, and much greater accuracy is possible than with a small scale and spot. The test, briefly, is as follows:—The cable is charged at some definite time, the full hour, or five, ten, &c., minutes past. The readings are first taken, say, with zinc, every thirty seconds; the first two or three readings are not so easy to catch, as the spot is then travelling fast, and the deflections must be carefully estimated that the division may be marked exactly at the thirtieth second. The spot, however, travels slowly after these readings, and nothing more than watchfulness is required till the fifty-ninth minute, when the operator is to look out for the next thing to be done, which is this:—What are called "earth readings" are to be taken for five minutes, and then five minutes' observation with the opposite current (to that in the cable) before finally discharging. At about the fiftieth section after the fifty-ninth minute the deflection may be noted, and instantly the galvanometer must be short circuited, and exactly at the sixtieth second (and sixtieth minute) the charging battery key released. This puts the cable to earth; then, as the charge going out of it acts on the mirror magnet in an opposite direction to one entering it, the galvanometer commutator (or reversing key, if used) must be reversed, that the spot may travel in the same direction as before. The galvanometer short circuit is then removed, and the spot appears travelling down, but very quickly at first, and the deflections are to be read at every minute. Just before the fifth minute reading the galva-

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nometer is to be short-circuited again (the deflection, however, being recorded as it then appears), and at the exact fifth minute the other. In this case the positive current is put on, and readings are to be taken for five minutes, and the test is finished (that is, the first half of it). The battery is not, however, taken off for about twenty minutes more, an interval allowed to enable the positive current to neutralise the negative, which has been saturating the cable for so long a time. After this period the battery key is released, and the cable is then put to earth. Two hours later the same operation is repeated, but with the reverse current; the test is exactly the same in all respects.

Our space is at present very limited, and we have to turn our attention to some of the duties involved in the shipping and submersion of cables, and shall therefore conclude this paper with an illustration of the signalling key and switch generally used at shore stations for communication with the ship and with the distant station. The mirror key in Fig. 45 is really the same thing as the ordinary testing key, but in practice is made to suit the convenience of the signalling operator. Every electrician ought to be able to read and send signals on the mirror. The dotted lines represent portions not seen in the actual key and switch; they are underneath, and so out of the way—one terminal goes to earth, and the other to line, that is to K in the switch. The handle of this

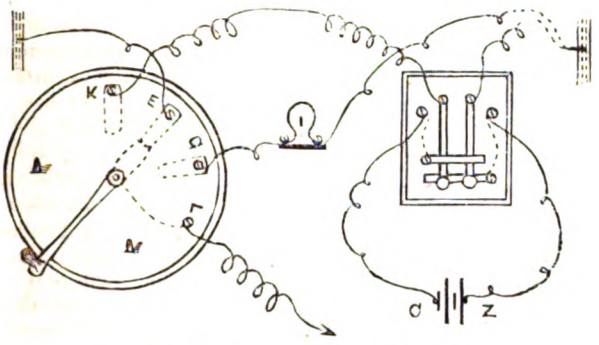

FIG. 45.—Signalling Key and Switch.

latter can be turned on to G when signals come in from the ship and are recorded on the mirror and thus read off; when the operator wants to send a signal or message the handle is turned on to K, and the signals go direct to the cable (by L always joined to the handle centre) without passing through the mirror, which would be useless; when turned on to E the cable is put to earth. The two little stops in the switch are merely pins or rests to keep the handle firm, either for receiving or sending, as when it rests against either the end is pressed against the connection plate at G or K. The earth terminal E is placed between G and K so as to put the cable to earth between receiving and sending. The pieces G, E, K are springs for safer contact by pressure with the handle terminal.

OPPOSITION TO ELECTRIC LIGHTING.—A meeting of delegates from the vestries of Kensington and St. Martin-in-the-Fields and the district boards of Holborn, St. Giles, and Westminster was held on Friday, April 20, at the offices of the Westminster District Board, 25, Great Smith-street, S.W., Mr. T. J. White (Westminster) in the chair, to consider the course to be adopted with reference to a communication received from the Board of Trade, forwarding copy of model provisional order proposed to be granted to the various electric lighting companies. The following resolutions were carried: "That this meeting is of opinion that it is undesirable for the Board of Trade to force electric lighting upon any district under present circumstances in opposition to the desire of the local authority." "That this meeting is of opinion that an extension of time should be granted by the Board of Trade, so as to allow full opportunity to the local authorities for considering the model clauses of the provisional order relative to electricity issued by the Board, and to give their replies thereto."

THE INSTITUTION OF CIVIL ENGINEERS.

The fifth of the series of six lectures on the Applications of Electricity was delivered on Thursday evening, the 19th of April, 1883, by Professor F. A. Abel, C.B., F.R.S., Hon. M. Inst. C.E. The subject was "Electricity Applied to Explosive Purposes." The following is an abstract of the lecture:—

In introducing the subject the lecturer indicated the principal advantages which it had been early observed would result from a certain mode of firing explosive charges by electric current instead of by the ordinary fuzes, the best of which had inherent defects, greatly limiting their use for any but the simplest operations. He traced the history and development of electric firing from the crude experiments of Benjamin Franklin, about the year 1751, through the various stages in which frictional electricity, volta-induction apparatus, and magneto-electric machines had supplied the means of generating the current, the tendency of late years being to revert to a modified form of voltaic battery for one class of work, and to employ dynamo-electric machines for another class. The history and development of the low-tension, or wire-fuse, and of the various fuzes employed with electric currents of high-tension, were also discussed, and their relative advantages, defects and performances were described.

The only sources of electricity which at present thoroughly fulfilled the conditions essential in the exploding agent for submarine mines were constant voltaic batteries. They were simple of construction, comparatively inexpensive, required but little skill or labour in their production and repair, and very little attention to keep them in constant good working-order for long periods, and their action might be made quite independent of any operation to be performed at the last moment.

When first arrangements were devised for the application of electricity in the naval service to the firing of guns and so-called outrigger-charges, the voltaic pile recommended itself for its simplicity, the readiness with which it could be put together and kept in order by sailors, and the considerable power presented and maintained by it for a number of hours. Different forms of pile were devised at Woolwich for boat and ship use, the latter being of sufficient power to fire heavy broadsides by branch circuits, and to continue in a serviceable condition for twenty-four hours, when they could be replaced by fresh batteries, which had in the meantime been cleaned and built up by sailors.

The Daniell and sand batteries first used in conjunction with the high tension fuse for submarine mining service were speedily replaced by a modification of the battery known as Walker's, which was after some time converted into a modified form of the Leclanché battery.

The importance of being able to ascertain by tests that the circuits leading to a mine, as well as the fuses introduced into that circuit, were in proper order, very soon became manifest; and many instances were on record in the earlier days of submarine mining of the disappointing results attending the accidental disturbance of electric-firing arrangements, when proper means had not been known or provided for ascertaining whether the circuit was complete, or for localising any defect when discovered.

The testing of the Abel fuze, in which the bridge, or igniting and conducting composition, was a mixture of the copper phosphide and sulphide with potassium chlorate, was easy of accomplishment (by means of feeble currents of high tension), in proportion as the sulphide of copper predominated over the phosphide. Even the most sensitive might be thus tested with safety; but when the necessity for repeated testing, or even for the passing of a signal through the fuze, arose, as in a permanent system of submarine mines, the case was different, this fuze being susceptible of considerable alterations in conductivity on being frequently submitted to even very feeble test-currents, and its accidental ignition, by such comparatively powerful test or signal currents as might have to be employed, became so far possible as to create an uncertainty which was most undesirable.

Hence, and also because the priming in these fuses was liable to some chemical change detrimental to its sensitiveness, unless thoroughly protected from access of moisture, another form of high-tension fuse, specially adapted for submarine mining service, was devised at Woolwich. This, though much less sensitive than the original Abel fuse, was sufficiently so for service requirements, while it presented great superiority over the latter in stability and uniformity of electric resistance; and, though not altogether unaffected by the long-continued transmission of test currents through them, the efficiency of the fuse was not affected thereby.

Although high tension fuses presented decided advantages in point of convenience and efficiency over the earlier form of platinum wire fuse, the requirements which arose, in elaborating thoroughly efficient permanent systems of defence by submarine mines, and the demand for a battery for use in ships which would remain practically constant for long periods, caused a very care-

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ful consideration of the relative advantages of the high and low tension systems of firing to result in favour of the employment of wire fuses for these services. In addition to the disadvantages pointed out there was an element of uncertainty, or possible danger, in the employment of high tension fuses, which, though fully eliminated by the adoption of voltaic batteries, in place of generators of high tension electricity, might still occasionally constitute a source of danger, namely, the possibility of high tension fuses being accidentally exploded by currents induced in cables, with which they were connected, during the occurrence of thunderstorms, or of less violent atmospheric electrical disturbances

Experiment, and the results obtained in military service operations, had demonstrated that if insulated wires, immersed in water, buried in the earth, or even extended on the ground, were in sufficient proximity to one onother, each cable being in circuit with a high-tension fuze and the earth, the explosion of any of the fuses by a charge from a Leyden jar, or from a dynamo-electric machine of considerable power, might be attended by the simultaneous ignition of fuses attached to adjacent cables, which were not connected with the source of electricity, but which become sufficiently charged by the inductive action of the transmitted current. It therefore appeared very possible that insulated cables extending to land or submarine mines, in which high tension fuses were enclosed, might become charged inductively during violent atmospheric electrical disturbances to such an extent as to lead to the accidental explosion of mines with which they were connected. In a report by Von Ebner on the defence of Venice, Pola, and Lissa, by submarine mines, in 1866, he refers to the accidental explosion of one of a group of sixteen mines during a heavy thunderstorm, as well as to the explosion of some mines, by the direct charging of the cables, through the firing station having been struck by lightning. Two instances of the accidental explosion of tension fuses by the direct charging of overhead wires during lightning discharges occurred in 1873 at Woolwich.

Subsequently an electric cable was laid out at Woolwich along the river bank below low water mark, and a tension fuze was attached to one extremity, the other being buried. About eleven months afterwards the fuse was exploded by a charge induced in the conductor during a very heavy thunderstorm.

In consequence of such difficulties as these experienced in the special application of the high tension fuses to submarine purposes, the production of comparatively sensitive low tension fuses, of much greater uniformity of resistance than those employed in former years, was made the subject of an elaborate experimental investigation by the lecturer. Different samples of comparatively thin wires, made from commercial platinum, showed very great variations in electrical conductivity. Very considerable differences in the amount of forging to which the metal, in the form of sponge, had been subjected, did not importantly affect either its specific gravity or its conductivity, and the fused metal had only a very slightly higher degree of conductivity than the same metal forged from the sponge. The conductivity of very fine wires could therefore be but slightly affected by physical differences in the metal, and the considerable differences in conductivity observed in different samples of platinum were therefore chiefly ascribable to variations in the degree of its purity. It appeared likely that definite alloys might furnish more uniform results than commercial platinum; experiments were therefore made with fine wires of German silver, and of the alloy of 66 of silver with 33 of platinum employed by Matthiessen for the reproduction of B. A. standards of electrical resistance. Both were greatly superior to ordinary platinum in regard to the resistance opposed to the passage of a current; German silver was in its turn superior to the platinum silver alloy; although the difference was only trifling in the small lengths of fine wire used in a fuse (0·25 inch), while the comparatively ready fusibility of the platinum silver wire contributed, with other physical peculiarities of the two alloys, to reduce the fine German silver wire to about a level with it. Moreover, the latter did not resist the tendency to corrosive action exhibited by gunpowder, and other more readily explosive agents, which had to be placed in close contact with the wire bridge in the construction of a fuze, while the platinum silver was found to remain unaltered under corresponding conditions. Experiments having also been made with alloys of platinum with definite proportions of iridium, the metal with which it is chiefly associated, very fine wires of an alloy containing 10 per cent. of iridium were eventually selected as decidedly the best materials for the production of wire fuzes of comparatively high resistance and uniformity, this alloy being found decidedly superior in the latter respect, as well as in point of strength (and therefore of managableness in the state of very fine wire, 0·001in. in diameter), to the platinum silver wire. The fuzes now used in military and submarine services were made with bridges of iridio-platinum wire, containing 10 per cent. of the first named metal.

The electrical gun tubes in the navy were fired by means of a specially arranged Leclanché battery, and branch circuits worked to the different guns; in broadside firing, it was important that the wire bridge of any one of the gun-tubes which was first fired should be instantaneously fused on the passage of the current, so as to cut this branch out of circuit; in this respect the comparatively fusible platinum silver alloy appeared to present an advantage, hence the naval electrical fuses were made with bridges of that alloy. Uniformity of electrical resistance had become a matter of such high importance in the delicate arrangements connected with the system of submarine mines, as now perfected, that the very greatest care was bestowed upon the manufacture of service electric fuses and detonators, which were in fact made, in all their details, with almost the precision bestowed upon delicate scientific instruments, and the successful production of which involved an attention to minutiæ which would surprise a superficial observer.

One of the earliest applications of electricity to the explosion of gunpowder was the firing of guns upon proof at Woolwich by means of a Grove battery and a gun tube, which was fired by a platinum wire bridge, a shunt arrangement being used for directing the current successively into the distinct circuits connected with the guns to be proved. When the high-tension fuze had been devised, gun tubes were made to which it was applied, and an exploder was arranged by Wheatstone, having a large number of shunts, so that as many as twenty-four guns might be brought into connection with the instrument, and successively fired by the depression of separate keys connected with each.

The firing of cannon, as time signals, was an ancient practice in garrison towns, but the regulation of the time of firing the gun, by electrical agency from a distance, appears first to have been accomplished in Edinburgh, where, since 1861, the time gun had been fired by a mechanical arrangement, actuated by a clock, the time of which is controlled electrically by the mean time clock at the Royal Observatory on Calton Hill.

Shortly after the establishment of the Edinburgh time-gun, others were introduced at Newcastle, Sunderland, Shields, Glasgow, and Greenock. The firing of the gun was arranged for in various ways; in some instances it was effected either direct from the observatory at Edinburgh, or from shorter distances, by means of Wheatstone's magneto-electric exploders. At present there were time-guns at West Hartlepool, Swansea, Tynemouth, Kendal, and Aldershot, which were fired electrically, either by currents direct from London, or by local batteries, which were thrown into circuit at the right moment by means of relays, controlled from St. Martin's-le-Grand.

About thirteen years ago, the electrical firing of guns, especially for broadsides, was first introduced into the Navy, with the employment of the Abel high-tension gun-tube and voltaic piles. The gun tubes then used were manufactured simply for the proof of cannon and for experimental artillery operations, and were of very simple and cheap construction. Experience proved them to be unfitted to withstand exposure to the very various climatic influences which they had to encounter in Her Majesty's ships, and in store in different parts of the world. The low-tension gun tubes, having a bridge of very fine platinum-silver wire, surrounded by readily-ignitable priming composition, were therefore adopted as much more suitable for our naval requirements.

The arrangements for broadsides or independent firing, and also for the firing of guns in turret ships, had been very carefully and successfully elaborated in every detail, including the provision of a so-called drill or dummy electrical gun tube, which was used for practice, and refitted by well-instructed sailors. The firing keys and all other arrangements connected with electrical gun firing were specially designed to ensure safety and efficiency at the right moment.

The electric detonators for firing outrigger torpedoes, or for other operations to be performed from open boats, corresponded, so far as the bridge was concerned, with the naval electric gun tubes, and were fired with a specially-fitted Leclanché battery. These electrical appliances were now distributed throughout the Navy, and the men were kept, by instruction and periodical practice, well versed in their use.

The application of electricity to the explosion of submarine mines, for purposes of defence and attack, received some attention from the Russians during the Crimean War under the direction of Jacobi; thus a torpedo, arranged to be exploded electrically when coming into collision with a vessel, was discovered at Yeni-Kale, during the Kertsch expedition in 1855. Some arrangements were made by the British, at the conclusion of the war, to apply electricity to the explosion of large powder charges for the removal of sunken ships, &c.,

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in Sebastopol and Cronstadt Harbours. In 1859, a system of submarine mines, to be fired through the agency of electricity by operators on shore, was arranged by Von Ebner for the defence of Venice, which, however, never came into practical operation. Early in 1860, Henley's large magneto-electric machine, with a supply of Abel fuzes, and stout india-rubber bags, with fittings to resist water pressure, were despatched to China, for use in the Peiho River, but no application appeared to have been made of them. The subject of the utilisation of electricity for purposes of defence, however, did not receive systematic investigation in England or other countries until some years afterwards, when the great importance of submarine mines as engines of war was demonstrated by the number of ships destroyed and injured during the war in America.

The application of electricity to the explosion of submarine mines was very limited during that war, but arrangements for its extensive employment were far advanced in the hands of both the Federals and Confederates at the close of the war; men of very high qualifications, such as Captain Maury, Mr. N. J. Holmes, and Captain McEvoy having worked arduously and successfully at the subject.

The explosion of submerged powder charges by mechanical contrivances either of self-acting nature or to be set into action at desired periods was accomplished as far back as 1583 during the siege of Antwerp by the Duke of Parma, and from that period to 1854 mechanical devices of more or less ingenious and practical character had been from time to time applied to some small extent in different countries for the explosion of torpedoes. The Russians were the first to apply self-acting mechanical torpedoes with any prospect of success, and had the machines used for the defence of the Baltic been of larger size (they only contained 8 or 9lb. of gunpowder), their presence would probably have proved very disastrous to some of the English ships which came into collision with and exploded them. Various mechanical devices for effecting the explosion of torpedoes by their collision with a ship were employed by the Americans, a few of which proved very effective. But although in point of simplicity and cost, a system of defence by means of mechanical torpedoes possessed decided advantages over any extensive arrangements for exploding submarine mines by electric agency, their employment was attended by such considerable risk of accident to those at whose hands they received application that, under many circumstances which were likely to occur, they became almost as great a source of danger to friend as to foe.

The most important advantages secured by the application of electricity as an exploding agent of submarine mines were as follow:—They might be placed in position with absolute safety to the operators, and rendered active or passive at any moment from the shore; the waters which they were employed to defend were therefore never closed to friendly vessels until immediately before the approach of an enemy; they could be fixed at any depth beneath the surface (while mechanical torpedoes must be situated directly or nearly in the path of a passing ship), and they might be removed with as much safety as attended their application.

There were two distinct systems of applying electricity to the explosion of submarine mines. The most simple was that in which the explosion was made dependent upon the completion of the electric circuit by operators stationed at one or more posts of observation on shore; such a system depended, however, for efficiency, on the experience, harmonious action, and constant vigilance of the operators at the exploding—and observing—stations, and was, moreover, entirely useless at night, and in any but clear weather.

The other, which might also be used in conjunction with the foregoing, was that of self-acting mines, exploded either by collision with the ship, whereby circuit was completed through the enclosed fuse, or by the vessel striking a circuit closer, whereupon either the mine, moored at some depth beneath, was at once fired, or the necessary signal was given to the operator on shore.

Continental nations had followed in our footsteps, in providing themselves with equipments for defensive purposes by submarine mines, and the Danes, Swedes, and Norwegians, had pursued the subject of submarine mines with special activity and success.

In the United States the subject of the utilisation of electricity as an exploding agent for war purposes was being actively pursued, and important improvements in exploding instruments, electric fuses, and other appliances had been made by Smith, Farmer, Hill, Striedinger, and others already mentioned, while no individual had contributed more importantly to the development of the service of submarine explosions than General Abbot, of the United States Engineers.

Illustrations of actual results capable of being produced in warfare by submarine operations had hitherto been very few, but of the moral effects of submarine mines there had already been abundant illustrations. In the war carried on for six years by the Empire of Brazil and the Republic of Uruguay and the Argentine Republic of Paraguay the latter managed by means of submarine mines to keep at bay for the whole period the Brazilian fleet of fifteen ironclads and sixty other men-of-war. In the Russo-Turkish war submarine mines and torpedoes were a source of continued apprehension, and the French naval superiority was paralysed during the Franco-German war by the existence, or reputed existence, of mines in the Elbe.

The application of electricity to the explosion of military mines and to the demolition of works and buildings had been of great importance in recent wars in expediting and facilitating the work of the military engineer. The rapidity with which guns, carriages, &c., were disabled and destroyed by a small party of men who landed after the silencing of the forts at Alexandria illustrated the advantages of electrical exploding arrangements, combined with the great facility afforded for rapid operations by the power possessed of developing the most violent action of gun-cotton, dynamite, &c., through the agency of a detonator.

The application of electricity to the explosion of mines for land-defences during active war was not an easy operation, inasmuch as not only the preparation of the mines, but also the concealment of electric cables and all appliances from the enemy, entailed great difficulties, unless the necessary arrangements could have been made in ample time to prevent a knowledge of them reaching the enemy.

But few words need be said to recall to the minds of civil engineers the facilities which the employment of electricity to explosive purposes afforded for expediting the carrying out of many kinds of works in which they were immediately interested. Electrical blasting, especially in combination with rock-boring machines, had revolutionised the operation of tunnelling and driving of galleries; and, although in ordinary mining and quarrying operations the additional cost involved in the employment of fuses, conductors, and the exploding machine, was not unfrequently a serious consideration, there were, even in those directions, many occasions when the power of firing a number of shots simultaneously was of great importance. There was little doubt, moreover, that accidents in mining and quarrying would be considerably reduced in number if electrical blasting were more frequently employed.

The conveniences presented by electric firing arrangements, under special circumstances, were interestingly illustrated by a novel proceeding at the launch of a large screw steamer at Kinghorn, in Scotland, which was recently accomplished by placing small charges of dynamite in the wedge-blocks along the sides of the keel, and exploding them in pairs, hydraulic power being applied at the moment that the last wedge was shot away.

In the deepening of harbours and rivers, and in the removal of natural or artificial submerged obstructions, the advantages of electric firing were so obvious that extended reference to them was unnecessary.

A substitute for electrical firing, which had been applied with success to the practically simultaneous firing of several charges, consisted of a simple modification of the Bickford fuze, which, instead of burning slowly, flashed rapidly into flame throughout its length, and hence had received the name of instantaneous fuze, or lightning fuze. The fuze burned at the rate of about 100 feet per second; it had the general appearance of the ordinary mining fuze, but was distinguished from the latter by a coloured external coating. Numerous lengths of this fuze were readily coupled up together, so as to form branches leading to different shot-holes, which might be ignited together, so as to fire the holes almost simultaneously. In the Navy this fuze was used as a means of firing small gun-cotton charges to be thrown by hand into boats when these engaged each other, the fuze being fired from the attacking boat by means of a small pistol, into the barrel of which the extremity was inserted.

OBITUARY NOTICE.—We have to record the death of Mr. William Cherry, the foreman of the mechanical, the fitting, and the erecting departments of the well-known firm of Messrs. Johnson and Phillips, telegraph engineers, Charlton, S.E. The burial took place on Wednesday at the quiet little Brockley Cemetery, and besides the chief mourners there were gathered together at the grave the heads of the firm, all the officials and many of the leading hands. It was the boast of the old gentleman that he had always been at his duties never later than six o'clock in the morning during the whole time he had held the position of foreman in the works, and it might literally be said that he actually died in harness, for up to the day before his death he was at his work as usual. Although not prominently known in the electrical world, Mr. Cherry was intimately associated with telegraphy. It was under his supervision that some of the first, now celebrated, lamps invented and patented by Mr. Brockie were made, and at the time of his death we are informed that heavy cable machinery, destined for the new Postal telegraph ship, was being carried out under his care at the works in Charlton.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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ANSWERS TO CORRESPONDENTS.

C. E. M.—*You had better read the recent Cantor Lectures by Professor S. Thompson. The lectures have been reprinted by the Society of Arts in pamphlet form, and cost one shilling. To your second question, concerning Rhumkorff's coils, yes.*

H. N. L.—*We do not think the South Kensington certificate worth anything, nor do we think a cart load of certificates would gain an appointment unless they were backed by practical experience. If you have made up your mind to enter into electric light work, or telegraphy, or telephony, we should advise you at the same time to make up your mind for hard work. Take any work that may be obtainable in the branch you select. If electric lighting, use your spare time to get theoretical knowledge of the subject and a practical knowledge of mechanical engineering. The best electric light engineers are those whose knowledge is not confined to electrical matters, but includes a good knowledge of practical and theoretical mechanics.*

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MR. CHAMBERLAIN AND THE ELECTRIC LIGHTING COMPANIES.

The deputation which waited on the President of the Board of Trade on Saturday last did not, we fear, come away particularly satisfied with their interview. It is somewhat difficult to make out what they went for, the reports of the proceedings, especially in respect to the speeches of the interviewers, being meagre and obscure. Only from Mr. Chamberlain's reply can we make out, with any degree of certainty, what the deputation wished him to concede, and what it was upon which he dismissed them unsatisfied. Judging, however, from information derived from newspaper reports, we are inclined to agree with the official President, and not with the representatives of the public companies. We may be wrong in this; but, if so, the deputation have themselves to blame in not making their grievances more widely known, so that they might have been fully discussed on their merits.

We have so often taken exception to the whole tenour of the Bill of which Mr. Chamberlain was the reputed father, and have so freely criticised his interpretation of it, that we shall not be suspected of partiality either for him or his scheme; but in the present instance he appears to have had both justice and common sense on his side, and we can take little exception to the answer he gave Mr. Bouverie and his following. The Electric Lighting Act stipulates, in respect to the contract between any electric lighting undertakers and the local authorities, that the former shall deposit, before taking up the streetways, a sum equal to half of the estimated cost of the work to be done—that is to say, work coming strictly under the head of street works. The proportion this would represent of the whole amount expended in laying down wires and installing the electric light must obviously be small; Mr. Chamberlain estimated it at only one-sixth of the total capital required. Yet the deputation strongly object to this arrangement, on the, as it seems to us, very inadequate ground that it was contrary to public policy, and, if insisted on, would prevent the public embarking their money in these undertakings, thus discouraging the improved illumination, which is everywhere admitted to be desirable.

Probably some stronger argument is capable of being framed against the objectionable clause; but, substantially, this was the one put forward on Saturday. That several highly respectable representatives of electric lighting enterprise joined in the protest, lame though it was, is not surprising. Their progress is being hampered and hindered at every step by vexatious opposition, or passive indifference, on the part of the local vestries, whose name is legion and whose powers are infinite. Anything likely to curtail those powers, or lessen their capacity for obstruction, would naturally be welcome to all undertakers alike, and as any rope is good enough to hang a dog with, the half deposit rule, under Schedule A, was as good as any other wherewith to strangle the local boards. On this point, however, Mr. Chamberlain stood up as a champion of local rights, and their assailants came away discomfited. Mr. Chamberlain is reported to have commenced by saying he regretted the tone of Mr. Bouverie's remarks. Probably by this time his feeling is shared by all the deputation, though the Minister's own tone was far from unexceptionable.

Leading off with this deprecatory observation, the President of the Board of Trade proceeded to exemplify the sort of tone a minister may adopt when addressing a deputation. "Mr. Bouverie seemed to speak," so Mr. Chamberlain's words are reported, "with a feeling of conscious virtue, and to criticise matters which were really beside the actual circumstances of the case." Now, it is unwise at all times not to stick to the point; but why a man should not speak with conscious virtue does not so plainly appear. Either the Minister of the trade of this country has ceased to believe in virtue, which does not speak well for the moral atmosphere of the department over which he has control, or else he did not believe in Mr. Bouverie's virtue—an expression of opinion

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which may be correct "tone" at the office of the Board of Trade, but which is universally eschewed at the respectable clubs in its immediate neighbourhood. Probably this tradesmanlike view of virtue in general, and of Mr. Bouverie's in particular, is peculiar to the present chief of the Board of Trade, who may, for aught we know, be smarting under the immediate sense of his responsibilities in calling into being and encouraging with inconsiderate haste a host of undertakings which have finally proved themselves to be deficient in the one only virtue worth having—namely, funds. On the other hand, with a catastrophe such as that which overtook a large undertaking company the previous day, and several others of the same kind impending, any man may be excused speaking with conscious virtue, if he has any; and it is not expedient to discourage the expression of it.

But, if the spokesman of the deputation meant to attribute similar virtue—that is to say, solvency—to all the would-be applicants for electric lighting contracts, he was clearly in error, and it was here he betrayed the weak side of his case. Mr. Chamberlain could retort that there were a lot of bogus companies in the field, whose object was to spend other people's money—he might have said to appropriate it—and that it was not in the interests of electric lighting in the long run that these ignorant and unscrupulous speculators should be allowed to discredit the business by failing to perform their obligations. We are bound to endorse this view of the case; and we cannot help feeling some surprise that a condition already imposed on the tramway companies, and unexceptionable on grounds of prudence and fair treatment of the local authorities, should be objected to by any company with money and science at its back. Local burdens are sufficiently oppressive already without their being saddled with the consequences of experimental financing.

SUPPLEMENT No. III.

This Supplement is, in reality, a Supplement to No. II., and is intended to be used in conjunction with it. The figures are readily obtained from the former Supplement, but it has been thought more convenient to have some such tabular extension as we now issue. The figures in Supplement No. II., as we have before stated, were taken because they were such as had been tested by considerable use in actual practice, and err upon the side of safety. We are now having a series of independent tests made to corroborate Professor Forbes's formulæ, and hope in due course to construct tables of a more scientific character founded upon these formulæ.

FIRE AT THE CANADIAN PARLIAMENT HOUSE.—Telegrams to the daily Press from New York have attributed the origin of the fire which recently occurred in the Parliament House at Quebec to the electric light installation there. In the absence of any trustworthy information as to the why and wherefore of the fire we may say this, that if it has been occasioned by the short-circuiting of wires, or by the use of currents too high for the wires which carried them, or by any similar mishap, then it must be put down to the bad workmanship of those who are responsible for the installation. However, it may turn out, after all, not to have been caused in this way, and not to be due to the electric light and its belongings. Of this we are positively certain, viz., that, where fires are started by electric light wires or fittings, gross carelessness and bad workmanship are the primary causes.

CORRESPONDENCE.

EARTHQUAKES AND THEIR ORIGIN.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Shortly after the disastrous earthquake at Chios in 1881, I had occasion to address a letter to you on the subject, containing some observations made during a series of years in this island, where strong shocks are periodical and slight ones very frequent.

I then pointed out to your readers that on one occasion my astatic galvanometer had been rendered temporarily useless for testing that day, owing to the needles having been strongly influenced by an evolution of the earth's magnetism both previous to and subsequent to a very smart shock. The instrument, however, returned to its normal state in a few hours' time, and continued so.

Unfortunately then my testing room was too far away from the town to enable me to rush there at any hour on the recurrence of a strong shock to verify the idea that earthquakes are solely attributable to a disarrangement of the earth's magnetic polarity.

Since last autumn, however, the cables' ends have been brought into the office, and I anxiously awaited an opportunity for verifying and confirming my previous observations. Of course, no such opportunity offered itself, and, despite a very severe winter, a continuance of hurricanes, and other violent atmospherical disturbances, we enjoyed (as I pointed out to you in my note of February 24) an especial immunity from earthquake shocks.

The generally-accepted theory out here, that unusual heat or cold, the filtration of rain through the earth intermixing with the internal gases, &c., cause earthquakes was entirely at fault, for, despite deluges of rain and weather unexampled for years, the earth remained perfectly quiescent. When the eruption of Etna the other day became known everybody at once felt relieved, fancying that the vent at the volcano would certainly prevent any similar subterranean explosion in our vicinity. This "theory," however, exploded, as I propose to show.

On Monday last, April 2nd, the wind, which all day had been due south, with atmosphere hazy, suddenly changed to north-east; in fact, for a short time and until the latter predominated, the wind was actually south north-east.

The following morning I had to test two sections—Zante-Corfu and Zante-Canea. The former cable gave its normal results unaffected in any way by telluric currents. On testing the latter section, a cable renowned for its extreme immunity from earth currents, a most remarkable phenomenon presented itself. Whilst testing for insulation the deflection of 90deg. would slowly rise to 200, fall to zero, and pass over to the opposite side 80 to 100 divisions of the scale.

The proportion was precisely the same with either twelve silver cells or thirty Menotti's, or with zinc or copper, and with the battery cut off the deflection slowly travelled about the scale exactly as the needles would move were a key drawn backwards and forwards in their vicinity.

After a careful observation I came to the decided conclusion that some magnetic disturbance was taking place, and, remembering my former experience, I remarked to my assistant, and afterwards during the day to several people, that within the twenty-four hours we should have a violent shock of earthquake.

Unfortunately, I could not get this section "freed" again during the day, but, from our difficulty in working, I clearly saw the disturbance continued, and, as I fully anticipated, and to my extreme delight, we had, at 4:10 a.m., one of the smartest shocks felt for the last two years.

By some strange coincidence I awoke to hear a sound similar to a heavy gun being drawn in the vicinity of the house, immediately followed by an increasing oscillation of the earth, which from its strength and duration portended a very violent shock. It lasted, possibly, four seconds, and it fortunately paused half way, giving you the idea of two different shocks, otherwise I am fully persuaded much damage

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would have been done to the town. Hastily dressing myself, I went down to my testing room with the intention of ascertaining the extent of the disturbance by placing in circuit any one of the cables not in use at that moment; but, precisely as on the former occasion, I found it impossible to get the spot of light to any constant zero, or any rational deflection with the current on the cable in circuit; and only by placing the directing magnet at right angles across the coils could I keep the light anywhere near zero. Later on, in the course of the morning, the galvanometer returned to its normal condition.

In my opinion it is impossible to attach too much importance to this fact, when it is considered that not only were the phenomena observed two years ago identically the same in the present instance, but that by a most fortunate coincidence I predicted, with the greatest confidence, that within the day an earthquake actually would take place.

It is also worthy of note that the direction of the earthquake was nearly due S.E. to N.W., or exactly parallel with the Cretan cable, on which the magnetic disturbance was observed the day previously.

That the introduction of submarine telegraphy has opened a most extensive field for deciding several important scientific questions is indisputable. The immense surface offered even by a short cable serves admirably the purpose of studying and decisively fixing upon the origin and cause of "earth" currents, the presence or approach of thunderstorms, and much valuable information referring to meteorology, besides the more important one, about which so little is absolutely known, of earthquake shocks.

I do not pretend to assert that the observations made have finally decided the question, but being fortunate enough to have the advantage of commanding a perfect "cobweb" of cables, passing all over this part of the world, so subject to earthquakes, I consider it my duty to give to your readers all the information my experience and position can from time to time collect.—Yours, &c., W. G. Forster,

Superintendent Eastern Telegraph Company.

Zante, April 4, 1883.

ELECTRICAL MACHINES AND THE TRANSMISSION OF POWER TO A DISTANCE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It would have been interesting to have seen the expression of blank astonishment gradually gathering on the face of your contributor whilst he was proceeding with the translation of M. A. Bandsept's letter. The writer begins by referring to Hospitalier's discovery that a leak in the line must have been favourable to Marcel Deprez's experiment, and after remarking that you will perhaps find his notes worthy of attention he informs you that "the complete solution of the problem of the transmission of power does not seem to him to be possible under actual working conditions." This is a gloomy prospect indeed; but, happily, your correspondent shows us how it can be improved. The remedy is to have two different machines, a generator without core and a receiver without wire. There will be no difficulty about the generator; dynamos without an iron core in their armatures have been made, and are fairly good machines. But I am not aware that machines without wire have yet been made. If we only knew how to do this, what large profits could be made on the manufacture of such machines. Perhaps your correspondent will favour the engineering world with a sketch or description of his motor, and thus earn the gratitude of all interested in the electrical transmission of power.

A dynamo the field magnets of which are not excited will, of course, work as a motor, though with very poor results, as I have found from actual experiment; but M. Bandsept must have meant the armature to be without wire, for he goes on to say that "this arrangement would suppress or diminish the counter electromotive force, and thus considerable progress would evidently be made." It would be equally reasonable to suggest a turbine without buckets in order that the free flow of water might not be interfered with. The writer is evidently not aware of the fact that the counter electromotive force is one of the elements which determine the amount of mechanical energy developed by the motor. To make his way of looking at the question perfectly clear, he gives a mechanical illustration by comparing the dynamo to a centrifugal ventilating fan. Why a couple of fans connected by a pipe should be "one of the most striking analogies of electricity" is, however, not quite so easy to see; and no engineer would ever dream of transmitting power by centrifugal fans—that is, not until he had discovered how, when "any obstacle compels the dynamic centrifugal action to alter its potential, the dynamical reaction thereby necessarily produced" can be done away with. What that exactly means I do not know, but M. Bandsept informs us that this desirable result can be attained by "simply so arranging matters that the air-current shall arrive at the paddles of the second fan at the exact moment when the transformation of the dynamical action is taking place there."

All this is puzzling enough to the average engineering mind, but the last part of the letter will, I venture to think, even puzzle the greatest men of science. A new problem is here darkly hinted at, and it seems to be this: Why not condense the electricity after it has passed through the machine? "We condense steam when it has given up its useful work; and are not our most powerful engines worked on this system?" The letter concludes with a recommendation to those interested to prosecute their researches in the direction indicated.

This last sentence makes me almost think that the whole letter is a practical joke intended for the special edification of some very young and innocent, but at the same time, very zealous disciples of electrical science.—Yours, &c.,

April 21, 1883. Gisbert Kapp.

INSULATING ELECTRIC LIGHT WIRES.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: With reference to the notice in your last issue of an invention by Messrs. Phillips, embodied in a patent for "making insulating bodies of electric light conducting wires non-inflammable," I should like to correct the impression that the application of tungstate of soda for the said purpose is novel. It is now more than twenty years ago that this substance was introduced into commerce for the protection of tissues and other substances against fire, and its application has been described in detail in Hofman's "Report by the Juries of the International Exhibition, 1862." Since then its use has been extended to various objects for this identical purpose. Therefore, it does not seem as if the application of tungstate of soda to rendering even those materials non-inflammable which were relatively little known at the time referred to could properly form the subject of a patent or be styled an invention.—Yours, &c.,

23, Burton-crescent, W.C., Chemist.

23rd April, 1883.

REIS'S TELEPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

Sir: It may, perhaps, interest the readers of *The Electrician* to read the *prospectus* which Reis issued with his telephones in August, 1863, of which I enclose for your inspection an original print, together with the accompanying translation. I may add that a copy of the prospectus (reprinted in Pisko's "Recent Apparatus of Acoustics") has been in the British Museum for the last dozen years, and another copy in my own possession for seven years. Written one month later than the letter to Mr. Ladd which has so lately been reprinted in your columns, it explains several of the obscurities in that letter. It is valuable also as showing, amongst other things, the function of the auxiliary apparatus which Reis used as a call-signal, and which in his letter to Mr. Ladd he had styled the "complementary telegraph."

The question raised by the letter of Mr. Farquhar in

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your columns as to whether the existence of this telegraphic signalling apparatus did not show that the instrument was intended only to transmit music is most satisfactorily answered by the prospectus and by the figures. In the first place, had the "complementary telegraph" been intended to make up for supposed deficiency of the telephone it would have been placed at the side of the receiving, not of the transmitting part of the apparatus. Its position at the side of the transmitter shows that it was put there to enable the person who was listening at the receiving end to telegraph back to the person who was singing or talking at the transmitter.

Further, the instructions given for signalling are a sufficient reply in themselves to the question raised by Mr. Farquhar. If the person who is listening to the receiver wants the person at the transmitting end to *talk*, he signals *two* strokes; if he is to *sing*, *one* stroke is signalled.

Lastly, a most curious commentary on Reis's utter unfamiliarity with the technicalities of telegraphy is afforded by the code which he suggests for the use of the person who wants to signal through the "complementary telegraph." Yet the Morse code was known in Germany long before 1863.

—Yours, &c.,
SILVANUS P. THOMPSON.

April 21, 1883.

REIS'S PROSPECTUS.

(Translation.)

Telephon.

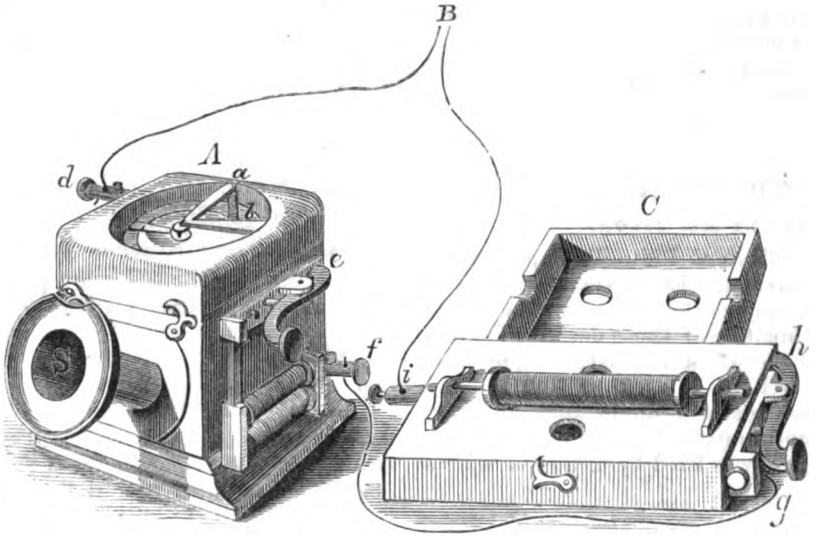
the circuit will be once opened and again closed for each full vibration, and thereby there will be produced in the iron wire of the spiral at Station C the same number of vibrations which there are perceived as a tone or combination of tones (chord). By imposing the little upper-case [oberkästchen] firmly upon the axis of the spiral the tones at C are greatly strengthened.

Besides the human voice (according to my experience) there can also be reproduced the tones of good organ pipes from F — $\overline{\overline{c}}$, and those of a piano. For the latter purpose A is placed upon the sounding board of the piano (of thirteen triads, a skilled experimenter could with all exactness recognise ten).

As regards the telegraph apparatus placed at the side, it is clearly unnecessary for the reproduction of tones, but it forms a very agreeable addition for convenient experimenting. By means of the same it is possible to make oneself understood right well and certainly by the other party. This takes place somewhat in the following manner. After the apparatus has been completely arranged one convinces oneself of the completeness of the connexion and the strength of the battery by opening and closing the circuit, whereby at A the stroke of the armature, and at C a very distinct ticking is heard.

By rapid alternate opening and closing at A, it is asked at C whether one is ready for experimenting, whereupon C answers in the same manner.

Simple signals can by agreement be given from both



Facsimile of illustration of Reis's Apparatus, taken from his Prospectus.

Each apparatus consists, as is seen from the above illustration, of two parts; the telephone proper A, and the reproduction-apparatus [receiver] C. These two parts are placed at such a distance from each other, that singing or the tones of a musical instrument can be heard from one station to the other in no way except through the apparatus itself.

Both parts are connected with each other, and with the battery B like ordinary telegraphs. The battery must be capable of effecting the attraction of the armature of the electromagnet, placed at the side at station A (3-4 6in. Bunsen's elements suffice for several hundred feet distance).

The galvanic current goes then from B to the screw *d*, thence through the copper strip to the little piatinum plate at the middle of the membrane, then through the foot *c** of the angular piece to the screw *b in whose little concavity a drop of quicksilver is put*. From here the current then goes through the little telegraph apparatus *e-f*, then to the key of Station C, and through the spiral past *i* back to B.

If now sufficiently strong tones are produced before the sound-aperture S, the membrane and the angle-shaped little hammer lying upon it are set in motion by the vibrations;

* *c* is not shown in the original of this illustration, and does not, therefore, appear in our engraving, but readers will readily see where it should be.—ED. *E.*

stations by opening and closing the circuit one, two, three or four times. For example,

1 beat = sing.
2 beats = speak, &c.

I telegraph words thus that I number the letters of the alphabet, and then transmit their numbers:—

1 beat = A,
2 beats = B,
3 „ = C,
4 „ = D,
5 „ = E, &c.

Z would accordingly be designated by 25 beats.

This number of beats would, however, appear wasteful of time and would be uncertain, wherefore I employ for every five beats a dactyl-beat (dactylusschlag), and there results:

— ∪ ∪ for E,
— ∪ ∪ and 1 beat for F, &c.

Z = — ∪ ∪, — ∪ ∪, — ∪ ∪, — ∪ ∪, — ∪ ∪, which is more quickly and easily executed, and easier to understand.

It is still better if the letters are represented by numbers which are in inverse proportion to the frequency of their occurence.

Friedrichsdorf, near Homburg-by-the-Height, Aug., 1863.

PHIL. REIS,
Teacher at L. F. Garnier's Institute for Boys.

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"OUR MAGAZINE."

TO THE EDITOR OF THE ELECTRICIAN.

SIR: *Re* my letter of April 7 and your reply in *Electrician*, No. 22, April 14, it is thought by some of us that the officials are now sufficiently strong to carry on a new magazine, and, as your *Electrician* is so widely circulated amongst us, that it is the best medium for inviting suggestions from them.

We are certainly desirous of trying it, as the service is so very different now to what it was thirty years ago.—Yours, &c., LEIGHBOURNE.

[To explain this letter we may say that our correspondent wrote to us suggesting that those employed in the work of the Postal Telegraph Department might now, with a better chance of success than resulted from previous efforts, support a magazine of a social and literary, rather than a technical, character. We hesitated to give a favourable opinion on the question, but it will be seen that our correspondent thinks us mistaken in our views, and we shall be glad to find that this is the case.—ED. *E.*]

HOW IT CAN BE DONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I should say that "Jer. Diddler" would have some difficulty in finding a "suitable" friend, *i.e.*, one willing to pay for Jeremy's lighting as well as his own. If the meters are all connected up to the mains in the same manner (as no doubt they would be), it is obvious that the current must pass through one or other of their meters, the friend's, of course, for choice.—Yours, &c., W. M. S.

MICROPHONIC CONTACTS.

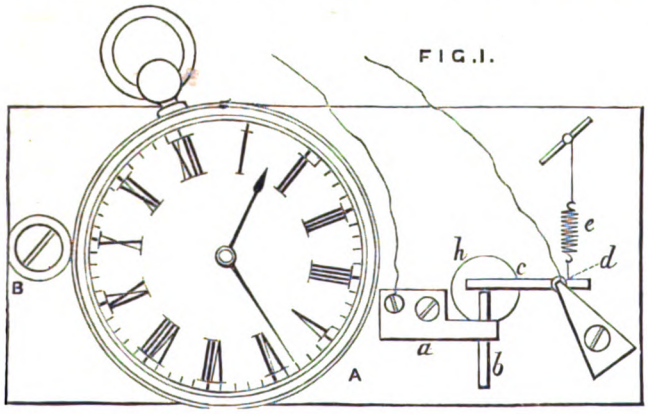
EXPERIMENTS BY MR. STROH.

After the reading of Mr. Shelford Bidwell's Paper* at the Society of Telegraph Engineers and Electricians, on the 12th inst., Mr. Stroh gave an account of the following experiments which he had made in continuation of those described by him at the society's meeting on the 8th March last, and published in our issue of the 17th March.

The microphone used was again of the hammer-and-anvil pattern, this form being most suitable for experiment.

On a little board, A, Fig. 1, was fixed by means of a brass

FIG. 1.



holder, *a*, a thin carbon rod, *b*. Against the end of the latter rested loosely another carbon rod, *c*, which was mounted on a little spindle, *d*. A small spiral spring, *e*, served to vary the pressure at the contact between the two carbons *b* and *c*.

The object of this arrangement was that the points of contact might be brought under a microscope, and for that reason the carbons, where they came into contact with each other, were made as flat as possible, and also thin at the edges, so that they might be fairly brought into the focus of the microscope.

The little board A, on which was placed a loud ticking watch as a source of sound, was fixed, at B, on a stand apart from that of the microscope, so that touching and adjusting the latter might not interfere with the microphone. A hole in the board at *h*, under the contact, was necessary to admit light from below.

In the circuit with the microphone were a telephone, a make-and-break key, and a small battery of one to three cells.

The two edges of the carbon contact appeared, although they were made with care, rough and jagged through the microscope, as represented in Fig. 2, and before the current passed, one or two of the projecting points were seen in contact only.

The tension of the spring for the first observation was such as was known by experience to be necessary to insure microphonic contact. By depressing the key, a current from two cells was now sent through the circuit, and the effect was closely observed by means of the microscope. What was noticed was a light, or, in fact, a burning away of the carbon; the two carbons came closer together during that burning, and presently another contact was made, and another light became visible. The carbons still approached, until three or four points were in contact, each of which was illuminated, and at last, as it appeared, when there were a sufficient number of points of contact for the greater portion of the current to pass, then the burning ceased, and the ticking of the watch could be heard in the telephone.

All this took place in the course of a few seconds; and while the microphonic condition remained no light could be seen at the points of contact. But as soon as the battery power was increased the burning commenced again, and continued until the area of contact was sufficiently enlarged, and consequently the resistance so far reduced that the

FIG. 2.

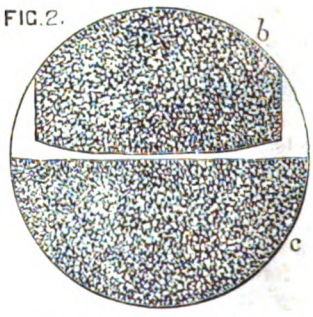
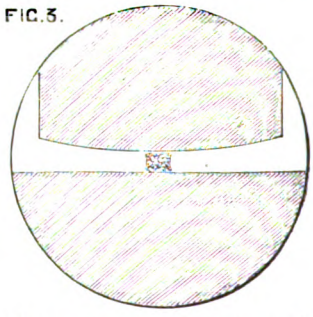


FIG. 3.



degree of heat which was still produced was below that which causes the combustion of the carbon.

This agrees with Mr. Bidwell's observation, viz.:—That the resistance of the contact falls with an increase of current.

The pressure at the contact was now reduced to a minimum by letting down the tension spring, so that the two carbons were only just in contact and no more, and when a current from the two cells was allowed to pass, a momentary burning at the contact, accompanied by a click in the telephone was observed; then followed an interruption, and the current would pass no more.

By making contact with the key many times, no trace of current could be detected with the telephone, showing that after the first passage of the current great resistance was established. This is also an effect observed and investigated by Mr. Bidwell.

The tension spring was now slightly tightened; this evidently caused the insulating film or substance which prevented the current from passing to be forced aside or broken through, for another current passed on making contact, but only for a moment, and then again an interruption occurred. This could be repeated several times, until the spring was wound so tight that the insulating substance was broken through as soon as it was formed, and then the well-known boiling or hissing noise which we hear when the microphone is out of adjustment could be heard in the telephone. Sometimes the noise was a perfectly clear, musical note, and by adjustment of the spring it occasionally became as shrill as a whistle.

It was found possible to adjust the microphone so that while still listening to the noise the watch could be heard as well, and whenever this was successfully accomplished the

* Part of this Paper appeared in our last, and the remainder will be found in another column of our present issue.

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tick of the watch was heard louder than under any other circumstances.

That experiment was made with a telephone of considerable resistance, which was now replaced by one of a very small resistance, only a few ohms, and an entirely different effect was obtained.

The spring was again let down, so that the carbons were only just in contact. A momentary burning was seen as before on passing the current, but the movable carbon was also driven away from the fixed carbon, and apparently remained repelled at some distance. Each time the circuit was completed by the key the movable carbon was repelled, and a continuous stream of sparks could be seen flying across the space.

The sound produced in the telephone by this effect resembled the crackling of burning wood. By tightening the spring the noise was frequently changed into a musical note, the pitch of which rose with the pressure.

By closer observation exceedingly fine dark lines could be seen which reached from every projection of the jagged edge of the loose carbon, right across the space to the fixed carbon. This showed that the movable or loose carbon was in a state of vibration, the amplitude of which was equal to the distance of the apparent separation of the two carbons.

This distance, which was considerable when the rate of vibration was low, became rapidly less as the rate was increased by tightening the tension spring, and a point was soon reached when the separation could no longer be seen, but was likely still to exist during the production of the higher sounds.

Another effect which was occasionally observed with the microscope during the production of the various noises above mentioned was that little fragments of carbon which probably became detached by their expansion by heat, but still remained between the electrodes, were in a state of agitation.

There can be no doubt that during the production of these singing, hissing, or boiling noises, the current cannot be a constant one, but that in the case of the former it must be intermitted and of equal periods, while in the case of the latter it is probably undulatory and of unequal or irregular periods.

It also appears evident that a current crossing a microphonic contact has a strong tendency to cause vibratory disturbances, and it seems, therefore, reasonable to suppose that during microphonic action, even when all is in good adjustment, the sound waves which are transmitted are accompanied by other vibrations which are due to the passage of the current itself.

The following reasoning has led to this supposition. Whenever it was possible to adjust the microphone so that the ticking of the watch could be heard during the production of singing or hissing noises, the *timbre* or quality of the sound of the ticking was exactly that of the hissing noise, and any change in the character of the latter was always accompanied by a corresponding change of the former.

It being a fact that sudden slight changes in the quality of sound are sometimes observed even when the adjustment of the microphone is perfect, that is to say, when no singing or hissing noises are heard, it must be that, whenever sound-waves are transmitted, these have super-imposed upon them other vibrations, possibly of a very high rate or pitch, which vary, and so produce change of *timbre* or quality. The latter would be the vibrations or disturbances produced by the passage of the current across the contact.

In the next experiment metallic contacts were substituted for the carbon ones. With platinum very good microphonic effects have been obtained whenever sticking could be avoided.

With a view to prevent sticking, a little oil was placed on the platinum contacts, but quite a different and unexpected phenomenon was observed. The oil by its capillary attraction of course remains surrounding the contact, and when the adjustment was made so that the ticking of the watch could be heard, little particles of dust or carbon which happened to be in the oil were seen in violent agitation, and to be spinning round with great rapidity.

It was puzzling for a time as to what caused the particles to be agitated in so violent a manner, but it appeared afterwards that it was probably the effect of heat. The oil seemed to be boiling at the point of contact even with a single cell, and when an exceedingly fine thread of smoke was observed arising from the contact it became evident that such must be the case.

A number of carbon particles were then placed upon the oil, and when the current was again sent through and allowed to continue for a minute or so, the whole of the carbon dust, which was at first violently rotated and started in all directions, accumulated by degrees round the point of contact, and at last built up a pillar which forced the electrodes wide apart and took the shape shown in Fig. 3.

Steel contacts were now substituted for platinum, and with them the same experiments turned out equally successful, but another curious phenomenon was observed—the black particles in the oil continued their movements for a considerable time after the current had been interrupted by the key. In some cases it took quite two minutes before they came entirely to rest.

Having also ascertained that a pillar could be formed with and without the carbon dust in the oil, the latter was now taken away altogether, and it was found that by a little humouring a pillar could be caused to grow even when the contacts were perfectly dry and clean.

This pillar while in course of formation had the appearance of being in a state of low incandescence, but it was concluded afterwards that it was only surrounded by a dull, red glow, which appeared to be really a succession of sparks running along the surface of the pillar.

In concluding his remarks, Mr. Stroh said that he does not think at present that the formation of the pillar is directly connected with microphonic action, but regards it more as a secondary effect. He deems it advisable, however, that all observed effects should be recorded, and that by collecting and compiling them we may help in time to unravel the mystery which still surrounds microphonic contacts.

AN EPISODE IN THE EARLY HISTORY OF THE TELEGRAPH.

BY J. J. FAHIE, MEMB. SOC. TEL. ENGS. AND ELECS.

(CONCLUDED FROM PAGE 539.)

All these experiments, conclusive as they were, had nevertheless little effect in advancing Alexandre's interests; they drew on him the commendations of the multitude, made his name known, but contributed nothing towards the attainment of his end, which was Paris, and the patronage of the First Consul, to whom only would he confide his secret. Having no money for the further prosecution of his plans, he now entered into partnership with a M. Beauvais, who was to supply all sums necessary, and to receive in return a quarter of the profits of the enterprise, Alexandre keeping to himself the secret of his invention until he had netted 60,000 francs by its exploitation, after which it was to become joint property. No sooner were these terms concluded than Beauvais, provided with the official accounts of the experiments at Poitiers and Tours, addressed himself to Napoleon, and solicited the honour of a trial in his apartments and in his presence alone. Napoleon, perhaps smelling gunpowder, declined the meeting, but referred the papers to Delambre, the illustrious academician and astronomer, who, some weeks later, returned a report of which the following is a free translation:—

"Report of Citizen Delambre on the Secret Telegraph of Citizen Alexandre, submitted to the First Consul by Citizen Beauvais:—

"The papers which the First Consul has charged me to examine do not contain sufficient details to enable me to form an opinion, nor, after the two interviews which I have had with Citizen Beauvais, am I able to do more than offer the merest conjectures on the advantages and disadvantages of the Secret Telegraph.

"Citizen Beauvais knows the secret of Citizen Alexandre, but he has promised to impart it to no one but the First Consul himself. This circumstance must make any report from me valueless, for how can one judge of a machine which one has neither seen nor understands?

"All that we know is that this telegraph is composed of two similar boxes, each having a dial, round whose face are marked all the letters of the alphabet. By means of a winch or handle the pointer of one dial is moved to any desired letter or letters, and, at the same instant, the pointer of the other dial repeats the

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same movements, and in exactly the same order. When these two boxes are placed in two separate apartments two persons can write and reply without seeing each other, and without being seen, and in such a way that no one can doubt the correspondence, which, moreover, can be carried on at any time, as neither night nor fogs can intercept the transmission.

"By means of this telegraph the governor of a besieged place could carry on a secret and continuous correspondence with a person four or five leagues distant, or even at any distance, and communication can be established between the two boxes as readily as one can hang a bell *(qu'on poserait un mouvement de sonnette)*.

"The inventor carried out two experiments with his machines at Poitiers and at Tours, in presence of the prefects and mayors of the respective places, and the official reports of these functionaries attest that the results were completely successful. Now, the inventor and his associate ask either that the First Consul will be pleased to permit of one of the boxes being placed in his apartment, and the other in that of the Consul Cambaceres, so as to give to their experiments all the *éclat* and authenticity possible; or, that he will accord an audience of ten minutes to Citizen Beauvais, who will then communicate to him the secret (of the telegraph), which is so simple that the bare description will be equivalent to a practical demonstration. They add that the idea is so natural as to leave little room to fear that it will ever occur to any *savant*. It is said, however, that Citizen Montgolfier divined it, after some hours' reflection, on a description of the apparatus which was given to him.

"After this statement, which is the substance of my conversations with Citizen Beauvais, a very few remarks must suffice. If, as one would be inclined to believe from the comparison with bell-hanging, the means employed comprised wheels, levers, and such like,* the invention would not be very surprising, and one could easily imagine the practical difficulties that would be encountered as soon as it was attempted to employ it over distances of several leagues.

"If, on the contrary, as the official report from Poitiers seems to show, the means of communication is a fluid, the inventor deserves much more credit for having discovered how to utilise it so as to produce, at any distance, effects so regular and so unfailing. But then one may demand, what guarantee have we for these effects? Neither the experiments at Poitiers, nor those at Tours, in which the distance was only a few metres, supply it. No more would the proposed experiment between the chambers of the First and Second Consuls. So long as the motive power remains a secret, one can never vouch for more than what one sees, and it will be entirely wrong to conclude, from the success of an experiment on a small scale, that like results will be obtained over more considerable distances. If the effect is only attainable at a distance of some few metres the machine ought to be sent to the scientific toy shops.

"If Citizen Beauvais, who offers to defray the expenses of an experiment, had proposed to carry it out in presence of commissioners appointed for the purpose, there could be no objection to granting his request; for, although an experiment on a small scale would not be very conclusive, still, it would enable us to see what might be hoped from a trial of a grander and more expensive nature. But Citizen Beauvais, without expressly decling a commission, desires, in the first place, to secure the testimony and approbation of the First Consul. It only remains, then, for the First Consul to say whether, in view of the little chance of success attaching to an invention so little proved, and announced as so marvellous, he will spare a few moments for the examination of a discovery of an artist, who is described as one as full of genius as he is devoid of scientific learning and of fortune.

"He makes a secret of his discovery, and I ought to judge it with severity, and according to the laws of probability; but the limits of the probable are not those of the possible, and Citizen Alexandre must be sure of his facts, since he offers to expose all to the First Consul. It, therefore, only remains for me to hope that the First Consul will grant him an audience, and that, in the sequel, he will have reason to welcome the inventor, and recompense worthily the author. "DELAMBRE.

"Paris, 10 Fructidor, an X."

With this most interesting document ends the story of the *Secret Telegraph*. In 1806 Alexandre was at Bordeaux taking out a patent for a machine for filtering the water of the Garonne for supplying the city; but, although the authorities seem to have afforded him every facility towards the accomplishment of his scheme, it was never carried out, through want of money. We next hear of him in 1831, when he submitted to the King, Louis Philippe, a project for steering balloons. He died soon after at Angoulême, leaving a widow, who died in 1833, at Poitiers, in extreme want.

Such is the sad story, as told by M. Gerspach, of one who must be regarded as a veritable pioneer in electric telegraphy; for, although Alexandre chose to surround his invention with an air of mystery, and preserved only too faithfully the secret of its action, we believe that he had, in effect, constructed a telegraph of the ABC sort, with static electricity as his motive power. Let us recollect that while he was still a young man, the invention of the Chappe semaphore and its wonderful performances were the theme of daily conversation; and that rival plans were being frequently started—some, semaphores more or less like Chappe's, and for night as well as day service; some, based on the properties of acoustics; and some again, on those of electricity. What more natural, then, than that Alexandre, a clever mechanician, and a man of a quick and vigorous imagination, should turn his attention to the subject.

Now, let us regard the apparatus as described by M. Cochon, in connection with the half admission that electricity was its basis, and that it was operated by a winch or handle, as mentioned by Delambre. Do not this handle, the box, the dial on the top, and the conductor recall the telegraph of Lomond, which was the wonder of Paris in 1787, and which has been already described in these pages.* The dial of Alexandre, it is true, is an immense improvement on the pith-ball indicator of Lomond, but that, too, had its prototype in the synchronous clockwork dial with which Chappe essayed an electric telegraph in 1790, and which, no doubt, was equally well known as the machine of Lomond. Indeed, the inference to us seems irresistible, that Alexandre took Lomond's and Chappe's contrivances as his basis, and built upon them his own improvements.

The only point that remains for consideration is, how did the working (? revolving) of the handle actuate the pointers? The explanation to our mind is not far to seek. Given an electrical machine inside the box, and a train of wheels behind the dial and in gear with the pointer, and it would be easy for a clever mechanician to make the repulsion of a sort of pith-ball electrometer (acting also as a pawl) against a discharging surface, and its subsequent collapse, give motion of a step-by-step character to the wheels, and, through them, to the pointer. The prime conductors of both machines would, under our supposition, be connected by a wire (probably concealed from view), and thus the movements of one pointer would be synchronous with those of the other.

Some writers, as Cézanne (*Le Cable Transatlantique*, Paris, 1867, p. 32), and Berio (*Ephemerides of the Lecture Society*, Genoa, 1872, p. 645), think it likely that Alexandre used the electricity of the pile, then newly discovered by Volta; but this is highly improbable, for, except in the form of the dry-pile, or through the intermedium of electro-magnetism, both of which were not then known, any number of cells that he could enclose in the box would be entirely inadequate to the observed effects. The use of a handle is of itself almost conclusive of the fact that an electrical machine was the active principle.

If we compare this machine with that constructed by our own Ronalds 14 years later (1816), it must be admitted to be decidedly superior; for while it was equally efficient as Ronalds', it was far simpler in construction. Of course neither instrument could be practicable over long distances, as we all know now.

* Forming, in fact, a kind of mechanical telegraph like the railway semaphores of to-day.

THE CHEMISTRY OF THE PLANTÉ AND FAURE ACCUMULATORS.†

PART V.

1. *Influence of Strength of Acid.*

In the second part of this communication in *Nature*, Vol. XXV., p. 461, when treating of the charging of the cell, we pointed out that in the electrolysis of dilute sulphuric acid between lead electrodes, two totally different reactions might be obtained. The positive metal becomes thinly coated with lead sulphate when the current employed is of small density, but with lead peroxide when the density of the current is of greater magnitude. This latter action is, of course, what takes place in the ordinary formation of a Planté battery. The chemical change, therefore, which goes on at the positive electrode is to a certain extent dependent upon the strength of the current. It appeared also of both theoretical and practical interest to

* That is, of Mr. Fahie's History. For all that is known of Lomond's Telegraph see Highton's *Electric Telegraph; its History and Progress*. London, 1852, p. 41.—ED. *E.*

† Reprinted from *Nature* for April 19. Parts I. and II. will be found reprinted from the same source in *The Electrician* for March 25, 1882, p. 309, Vol. VIII., and Parts III. and IV. in our issue for November 11, 1882, p. 612, Vol. IX.

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determine whether the chemical change was also influenced by the strength of the acid employed. Our experiments consisted in passing a current of uniform strength, about 1 ampere, between electrodes of lead, 12 square inches in size, in varying strengths of sulphuric acid, and estimating in each case the amount of oxygen fixed by the positive electrode. We determined this for successive five minutes of time, and as such actions are not always very uniform, we made in each instance more than one experiment. The results are given in the following table :—

Strength of acid.	Expt.	Percentage of oxygen fixed.				
		First 5 mins.	Second 5 mins.	Third 5 mins.	Fourth 5 mins.	Total.
1 to 5	I.	38·1	28·6	28·6	33·3	128·6
	II.	39·5	30·2	25·6	30·2	125·5
1 to 10	I.	43·4	38·7	29·2	34	145·3
	II.	44·1	39·3	29·3	34·9	147·6
1 to 50	I.	48·3	39·6	35·3	22·4	145·6
	II.	46·2	43·9	23	30	143·1
	III.	54	40	35·3	35·5	165
1 to 100	I.	42	38·3	33·9	29·5	143·7
	II.	42·4	40	37·8	35·5	155·7
	III.	51·1	44·2	34·9	34·9	165·1
1 to 500	I.	46·6	32·6	27	27	132·6
	II.	46·4	27	27	18	118·4
1 to 1000	I.	90·6	81·1	76·4	57·5	305·6
	II.	90·8	77	72·3	63·1	303·2

It appears from this that the strong sulphuric acid (1 to 5) is not quite so favourable to the action as the more dilute (1 to 10), but that between this latter proportion and 1 to 500 there is no great difference in the amount of oxygen fixed, and, therefore, of corrosion of the plate. The appearance of the plate in every instance indicated the formation of only lead peroxide. With sulphuric acid diluted with 1,000 parts of water, the amount of oxygen fixed, and, therefore, of corrosion, was at least doubled, while the chemical action was very different. On parts of the electrode, streaks of a mixture apparently of the yellow and puce-coloured oxides were seen. On other parts a white substance formed and was easily detached, falling in clouds into the liquid. Where this latter action took place, the plate was visibly the most corroded. This white substance gave an analysis SO_4 equivalent to 73·6 per cent. of lead sulphate, suggesting the idea that it was a basic sulphate of the composition $2\,PbSO_4, PbO$, which would require 73·1 per cent. As the peroxidation of the lead is required, and the corrosion of the plate is to be avoided as much as possible, it is evident that this extremely dilute acid must be avoided. It has already been shown that if the sulphuric acid is entirely removed from solution, as sometimes happens in an accumulator, the lead is simply converted into the hydrated protoxide, and therefore corroded without any good effect.

2. *Function of Hydrogen.*—In the formation of a secondary cell, after the complete reduction of oxide or sulphate to metallic lead, bubbles of hydrogen gas are seen to escape from the lead plate. It has been assumed that a portion of this is occluded by the lead, or in some other way enters into association with it, and it has been supposed that this hydrogen compound may play an important part in the subsequent production of electromotive force. It therefore appeared desirable to obtain experimental evidence as to whether hydrogen is so absorbed. The process we adopted for this purpose was founded upon the observation of Graham that hydrogen associated with palladium reduced ferri to ferro-cyanide of potassium, and that generally in the occluded condition the element was more active chemically. We had previously ascertained that hydrogen associated with other elements, as platinum, copper, and carbon, was capable of reducing potassium chlorate to chloride. This method seemed to give trustworthy results, and therefore we applied it in this instance. As the result of several trials, however, we found that the amount of hydrogen associated with the reduced lead was almost inappreciable. Small as this quantity is, however, it is by no means impossible that it may be the cause of the exceedingly high electromotive force observed for the first few moments, on joining up a completely formed cell immediately after its removal from the circuit of the charging current. This, however, may be due, as Planté imagined, to the gaseous hydrogen itself. The principal if not the only function of the hydrogen of the water or sulphuric acid is, therefore, that of reducing the lead compounds.

By a totally different process Professor Falkland has very recently come to the same conclusion as ourselves in regard to the exceedingly small amount of occluded hydrogen.

3. *Evolution of Oxygen from the Peroxide Plate.*—Planté noticed a small escape of gas from the negative plate of his cell immediately after its removal from the influence of the charging current. This he attributed to a decomposition of water by means of local circuits between the peroxide and the subjacent lead plate in contact with it.

The explanation we gave in our first paper (*Nature*, Vol. XXV., p. 221) of the local action which goes on at the negative plate does not account for the escape of any gas—either oxygen or hydrogen. We therefore thought it of interest to ascertain the nature, and if possible the origin, of the gas noticed by Planté.

We found that the escaps of gas from a Planté negative plate was very slight, and soon ceased ; but we observed that it became much more pronounced when the temperature of the electrolytic liquid was raised. In order to get a sufficient quantity of the gas for examination, we prepared a negative plate according to the procedure of Faure, and then heated it in dilute acid, with an arrangement for collecting the gas as it was evolved. The amount of gas was still very small in comparison with that of the peroxide, but a sufficient quantity was collected to enable us to ascertain that it was oxygen. We next heated some of the electrolytic peroxide apart from the lead plate, and again noticed a similar evolution of gas, which was also found to be oxygen. This shows, therefore, that it was not a result of local action.

The gas has generally some odour of ozone, and on testing the dilute acid between the plates of a Planté cell we always found traces of something that bleached permanganate of potassium, and which might be either ozone or peroxide of hydrogen.

The origin of the gas noticed by Planté may be easily attributed to the oxygen which always passes off in quantity from the peroxide plate during the process of "formation." It is only necessary to suppose that some of this becomes condensed on the peroxide, and is gradually eliminated from it when the surrounding conditions are changed. But the matter is capable of another explanation. If peroxide of hydrogen be really formed in the liquid, it will exert its well-known influence on higher oxides, namely, that of reducing them and itself at the same time. As a matter of fact, if peroxide of lead is dropped into peroxide of hydrogen oxygen is evolved.

4. *Temperature and Local Action.*—Planté has recently pointed out that an elevation of temperature facilitates the formation of his secondary cell (*Comptes Rendus*, August, 1882). The character of the chemical changes which took place at the negative plate led us to think it exceedingly probable that this increase in the rate of formation arose from an augmentation in the amount of local action. Experiment showed such to be the case. Pairs of similar negative plates on Planté's model were allowed to remain in repose at 11deg. C. and 50deg. C. respectively, and the formation of the white sulphate was visibly more rapid at the higher than at the lower temperature. The same is also true with negative plates prepared by Faure's process. Thus we found that two similar plates kept in repose for an hour, the one at 11deg. C. and the other at 50deg. C., formed by local action 2·6 and 7·4 per cent. of lead sulphate respectively. On two other plates the proportions were 7·6 and 9·5 per cent. respectively. These observations, of course, by no means exclude the idea that an increase of temperature may facilitate the other chemical changes that take place in the formation of a lead and lead-oxide cell.

J. H. GLADSTONE and ALFRED TRIBE.

THE ROYAL SOCIETY.—The following are the names of the candidates for the fellowship of this society who have been selected by the council to be recommended for election on June 7: —Surgeon-Major J. E. Tierney Aitchison, Dr. J. Crichton Browne, Surgeon-Major G. E. Dobson, Dr. J. Matthews Duncan, Professor G. F. Fitzgerald, Mr. W. Flight, Rev. Percival Frost, Dr. D. Gill, Mr. C. E. Groves, Mr. Howard Grubb, Mr. J. N. Langley, Professor A. W. Reinold, Mr. R. Trimen, Mr. J. Venn, Mr. J. J. Walker. The annual soirée of the society was held at Burlington House on Wednesday evening. Mr. John Evans received the guests in the absence of Mr. Spottiswoode, the President, who is on the continent. Many interesting scientific instruments were shown. Professor Hughes's torsion balance, Stroh's apparatus for illustrating the resemblance between sonorous vibrations and magnetism, Sabine's photometer, and a number of instruments by the Messrs. Elliott were also to be seen. Vice-Admiral Selwyn showed two electrometers, with which he carried out a somewhat novel experiment.

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ON MICROPHONIC CONTACTS.*

BY SHELFORD BIDWELL, M.A., LL.B.

(CONCLUDED FROM PAGE 550.)

TABLE IX.

Showing for different pressures the effect of increased current in first permanently reducing the resistance of the carbon contacts, and after a certain point (depending upon the pressure) greatly increasing it.

R_1 = Resistance with current in first column of table.
R_2 = Resistance with very weak current, obtained by inserting 10,000 ohms in the circuit.

Current.	Pressure ·05 gramme.		Pressure ·5 gramme.		Pressure 2·5 grammes.		Pressure 5 grammes.	
	R_1	R_2	R_1	R_2	R_1	R_2	R_1	R_2
Amperes.								
·01	38	62	10·2	10·3	4·8	4·8	2·60	2·6
·05	21	38	9·7	10·1	4·6	4·7	2·54	2·6
·1	Inf.		8·1	9·3	4·4	4·7	2·37	2·5
·2			6·3	8·4	4·0	4·5	2·23	2·4
·3			Inf.		3·7	4·3	2·11	2·3
·4					3·6	4·2	2·01	2·3
·5					Inf.		1·95	2·2
·6							1·90	2·2
·7							Inf.	

NOTE.—The resistance marked "Inf." was so great that the needle of the tangent galvanometer was not deflected from zero.

The experiments made with metals were less numerous than those with carbon. Metallic loose contacts were found to be even more uncertain in their action than those of carbon, and to obtain a really fair average of results a very great number of measurements would be required. Under precisely the same conditions, as nearly as they could be reproduced, the results obtained were frequently very different. Nevertheless, it has been possible to bring out with sufficient distinctness some remarkable peculiarities in the behaviour of metallic contacts.

The metal principally used was bismuth, which was selected on account of its high specific resistance, but a few experiments were also made with copper and platinum. The cylinders of bismuth and copper were of nearly the same diameter as those of the carbon previously used—6 mm. The platinum was prepared by soldering wires of that metal upon cylinders of brass. The balance already described and shown at Fig. 1 was used in the same manner as before.

The first unexpected phenomenon which attracted notice in working with bismuth was the very great permanent fall in the resistance which was produced by an ordinary current with light pressures. Using a single Leclanché cell, the lightest contact—the pressure being certainly less than ·01 gramme—failed to give a higher resistance than 9 ohms; but with 400 ohms inserted between the battery and the Wheatstone bridge, a pressure of ·35 gramme gave a resistance which on different occasions varied between 73 and 110 ohms. When once, however, the resistance has been reduced by a strong current, the changes which occur when feebler currents are used are comparatively small, unless, of course, the points of contact are first separated. Of the nature of such changes I shall say more presently. Table X. gives a few measurements, using one Leclanché cell—(1) with a resistance of 300 ohms between the cell and the bridge; (2) without the 300 ohms. It will be understood that the bismuth cylinders were separated from each other every time the weights were changed.

TABLE X.

Bridge measurements of the resistance of bismuth contacts under different pressures.

Pressure.	Resistance of bismuth contact with 300 ohms between battery and bridge.	Resistance when the 300 ohms are removed.
Grammes.	Ohms.	Ohms.
·5	60	1·9
2·5	37·2	1·4
5	5·4	1·7
7·5	7·7	·2
10	·8	·8
15	·6	·5
25	·14	·14

The effect in question is most marked with small pressures; with comparatively high pressures it quite disappears.

This phenomenon is accompanied by another. After the passage of the current which has caused the resistance to be so remarkably diminished, the bismuth cylinders are found to adhere to each other, a quite appreciable force being necessary to separate them. This effect, which is common to all metals, has been thoroughly investigated by Mr. Stroh, a description of whose experiments is given in the *Journal of the Society of Telegraph Engineers*, Vol. IX., p. 182. I shall, therefore, say nothing more about it, except that I have succeeded in causing two pieces of very thin platinum wire to stick to each other with a current of about a milliampere. Mr. Stroh attributes the effect to fusion.

* A paper read at the meeting of the Society of Telegraph Engineers, April 12, 1883.

TABLE XI.

Showing variations produced in the resistance of bismuth contacts by using small and large currents alternately.

Current.	Resistance of bismuth contact with pressure of		
	·5 gramme	1 gramme.	5 grammes.
Amperes.			
·01	8	2·12	1·50
·5	1·27	1·27	1·22
·01	1·22	1·21	1·22
·5	1·27	1·26	1·22
·01	1·22	1·21	1·22

A third apparent anomaly is the following:—A *small* weight being in the scale-pan, let a weak current be caused to pass through the points of contact; the resistance will be found to be high. Let a strong current be passed, and the resistance will begreatly diminished. Once more let the current be reduced to its original strength; the resistance will not rise to its original value; it will not, in fact, rise at all; it will be still further diminished. The following table gives examples of this experiment with pressures of ·5, 1, and 5 grammes. In the last case there is no change after the first fall of resistance.

Table XII. further illustrates the effect with greater variations of current and of weight, but in the experiments to which it relates the strongest current was used at first. As before, the bismuth cylinders were separated only when the weights were changed.

TABLE XII.

Effect of varying current upon the resistance of freshly scraped bismuth contacts.

Current.	Resistance of contact in ohms with pressure of				
	·25 grm.	·35 grm.	·5 grm.	1 grm.	2 grms.
Amperes.					
·5	1·52	1·39	1·55	1·33	1·35
·3	1·40	1·35	1·49	1·30	1·33
·1	1·37	1·33	1·45	1·28	1·32
·05	1·35	1·33	1·44	1·28	1·32
·01	1·18	1·32	1·41	1·28	1·32
·05	1·55	1·33	1·46	1·29	1·32
·1	1·72	1·34	1·47	1·29	1·33
·3	1·79	1·39	1·55	1·31	1·34
·5	1·49	1·43	1·61	1·33	1·35

REMARK.—With *clean* bismuth, decrease of current strength is accompanied by decrease of resistance.

In order that this experiment may be successful, it is necessary that the surfaces in contact should be absolutely clean. Unless they are scraped immediately before the measurements are made, the opposite effect may result—that is (after the first great fall of resistance), diminished current may produce increased resistance.

Table XIII. gives the measurements, with the same currents as before, when the bismuth was first rubbed with the finger, instead of being scraped as had been done in the previous experiments.

TABLE XIII.

Effect of varying current upon the resistance of bismuth contacts when the metal has been rubbed with the finger.

Current.	Resistance of contact with pressure of		
	·35 gramme.	·5 gramme.	1 gramme.
Amperes.			
·5	1·30	1·30	1·22
·3	1·75	1·46	1·28
·1	1·92	1·69	1·29
·05	1·83	1·92	1·29
·01	1·95	2·29	1·29
·05	1·89	2·07	1·28
·1	1·87	1·98	1·28
·3	1·77	1·72	1·27
·5	1·46	1·45	1·27

REMARK.—When the metal is *not perfectly clean*, decrease of current strength is accompanied by *increase* of resistance.

I think these effects admit of a simple explanation. When the surfaces of the bismuth are clean, contact takes place entirely through the metal. The current heats the metal at the points of contact to an extent which depends partly upon the current strength; and the resistance, in accordance with the general law, increases with the temperature; strong currents will therefore give higher resistance than weak ones. When, on the other hand, the surface is not clean, a film of oxide or some foreign substance is interposed, the resistance of which, like that of carbon, is higher with a weak current than with a strong one.

It is probable that similar effects occur with metals of lower specific resistance than that of bismuth; but their observation is very difficult, and requires more delicate apparatus than that at my disposal. Thus, of 40 measurements made with platinum contacts, 19 results were favourable to the theory, 10 adverse to it, and 11 neutral. With copper the indications were even more uncertain.

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The resistance of bismuth contacts at various pressures was then measured with fixed currents of ·1, ·01, and ·001 ampere, the method used being the same as in the case of carbon. The mean of several series of such measurements is given in Table XIV., which reveals the existence of a more or less definite law, though the results of the experiments did not agree very closely among themselves.

TABLE XIV.

Effect of pressure upon resistance of bismuth contacts with constant currents.

Pressure.	Assistance of contacts with		
	·1 ampere.	·01 ampere.	·001 ampere.
Grammes.			
·05	5	20·82	182
·1	2	16·92	143·3
·15	2·5	14·60	97·8
·2	3·9	12·60	46
·25	2·6	10·05	41·6
·3	2·4	6·35	16·9
·35	2·1	4·12	21·6
·4	1·9	2·37	30·6
·45	1·5	1·60	18·3
·5	1·45	1·47	3·8
1	·95	1·35	—
1·5	·85	·70	—
2	·90	·62	—
2·5	·70	·30	—
3	·50	·15	—
3·5	·55	·07	—
4	·35	·05	—
4·5	·25	—	—
5	·15	—	—

Repeating with bismuth the experiments already described in the case of carbon, it was clear that the diminution of resistance effected by pressure is generally of a permanent nature, continuing to a great extent after the pressure has been removed (so long as the points of contact remain undisturbed), and thus reversing the case of carbon. With strong currents the variations of resistance were so uncertain and irregular that accurate measurements were impossible; but with a resistance of 300 ohms between the battery and the bridge the effect is very clearly marked. The results of the experiments thus made are contained in Table XV.

TABLE XV.

Showing great permanent effect of pressure upon the resistance of bismuth contacts.

Pressure.	Resistance of bismuth contacts.					
Grammes.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
·5	10·9	37·5	16·3	14·5	25·5	62
3·0	1·3	1·7	·5	1	1·1	1·8
·5	1·5	1·7	·5	4·5	5·5	15

NOTE.—In the last three cases the apparatus for removing the additional weight worked badly, and caused a slight vibration of the scale-pan.

The points of contact were of course changed for each series of observations, and it should be noted that in the case of the last three (which were not made on the same day as the others) I was less successful in arranging the lever so as to secure perfect freedom from oscillation when the weight was changed.

At the meeting of this society, held on March 8, Mr. Stroh gave an account of a method which he had devised for observing the movements performed by the horizontal carbon rod of an ordinary microphone when the instrument is in action. He attached a small mirror to the carbon, from which a beam of light was reflected to a wall, the distance of which was such that the movement of the spot of light was 2,000 times greater than that of the carbon at the point of contact, and it was found that if a current from three bichromate cells was passed through the microphone, when it was so adjusted as to be in the best working condition, the "spot of light remained steadily deflected downwards," moving through a space of one millimetre, and returning to its former position when the current was interrupted. This, Mr. Stroh says, in an article which he has since published (*Electrician*, Vol. X., p. 429), "seems to indicate that during the time when the carbons are really in what is called microphonic contact they are not in contact at all, or, at all events, there is a repellent action at the point of contact."

It occurred to me that additional light might be thrown upon some of the phenomena which I have investigated by the application of Mr. Stroh's method, and I began by repeating the experiment almost exactly as he describes it. I at first found, as he did, that the effect only occurred when the microphone was so adjusted that the ticking of a watch laid upon the base could be distinctly heard in a telephone which was in the circuit. But with the high electromotive force of three bichromate cells it was exceedingly difficult to get the microphone into good working condition, or to keep it so for any length of time. A tangent galvanometer was then inserted in the circuit, and it at once became evident that when the condition of the microphone was at its best the current was strongest. It appeared probable, therefore, that the magnitude of the apparent repulsive effect depended merely upon the strength of the current which was passing at the moment, and that the excellence of the microphonic effect had really nothing to do with the matter. The upper carbon was therefore pressed down with a weight too heavy to admit of the ticking of the watch being heard, and a steady current was thus secured without any difficulty. It was now found that the repulsive effect was almost, if not quite, as great as it was when the carbons were in loose contact, and little doubt was left that the phenomenon was merely a case of expansion due to the heating effect of the current. Cylinders of bismuth were then substituted for the carbon rods, and a similar effect was produced, the movement of the spot of light being somewhat greater than it was with carbon. With copper the apparent repulsion was rather less than with carbon, but perfectly well marked. Lead was then tried, being chosen on account of its high coefficient of expansion and its inferior conductivity for heat and electricity, and, as was expected, the deflection of the spot of light was very considerable, being about six times as great as in the case of carbon.

One or two other curious results are worth noting. In the case of metal contacts, when the pressure was slight, the first effect of a small current was to produce closer contact; as the strength of the current was gradually increased, the contact became more and more close; when the circuit was broken, the Stroh effect occurred, and the contact became apparently still closer. This observation is evidently connected with the fact already discussed, that a current through loose metallic contacts causes a permanent decrease in their resistance. The same thing occurs when carbon contacts are used, but it is well marked only when the contact is exceedingly light, and is, I believe, due to the combustion of the minute projecting particles upon which the carbon rod rests. Finally, an attempt was made to exaggerate the effect by multiplying the number of carbon contacts. Twelve small pieces of carbon shaped like whip-top were arranged in an upright tube of ebonite, which they loosely fitted. The lower carbon was fixed, and the upper one had a knife-edge upon which rested a horizontal carbon rod with a mirror attached. A current through this arrangement produced a deflection five or six times as great as in the case of the single contact. It now became possible to observe that the whole effect was *not* absolutely instantaneous as it had previously appeared to be, a slow movement of the image in the upward or downward direction continuing for two or three seconds after the circuit had been opened or closed. When a single long piece of carbon was substituted for the small pieces the effect was similar, but not so great.

The little carbon balance (Fig. 1) was joined up in circuit with the apparatus just described, and it was observed that with a continuous current the magnitude of the repulsive effect could be varied by altering the weights in the scale-pan. This experiment was much more effective when an Edison carbon telephone was used instead of the balance. Pressing the diaphragm with the finger caused the spot of light to move to an extent depending upon the pressure.

It naturally occurred to me that a *receiving* microphone might easily be made by slightly modifying the apparatus to which the mirror was attached. A dozen top-shaped carbons were placed end to end in a glass tube; the bottom one was sealed in, and attached by a wire to a binding screw; the upper one, which was connected by a wire to a second binding screw, was made to press gently upon the centre of a mica diaphragm, on the other side of which was a steel spring to increase its elasticity. Using 12 Leclanché cells and an Edison transmitter, it was found quite possible to carry on a conversation, and very little adjustment was necessary. The instrument, of course, operates through expansion by heat, the action being exactly similar to that of the platinum wire in Mr. Preece's thermal telephone receiver; and I have little doubt that the operation of all receiving microphones which have been constructed may be explained in the same way.

Application to the Microphone.—The results of the experiments described in this paper may, perhaps, throw some light on a matter which has never hitherto been fully explained. Why does carbon give far better results than any metal when used in the microphone? It seems to me that this question may be very easily answered. The mere fact that a current causes delicately adjusted metal contacts to adhere to each other is sufficient to account for the superior efficiency of carbon. It is possible, indeed, to transmit articulate sounds by means of a metal microphone, as is proved by some of Professor Hughes's earliest experiments, but the action of such an instrument, as compared with one of carbon, is extremely uncertain and imperfect. This is no doubt due to the fact that, although vibrations corresponding to the fundamental tone are easily produced, the minute superimposed vibrations due to the upper partials, upon which depends the distinctive character of a particular sound, are, owing to the adhesion, very imperfectly represented, if not entirely lost.

At a recent meeting of this society Mr. Munro exhibited a metallic microphone, in which, by the ingenious use of iron gauze, the current is divided among a great number of points, at each of which its heating effect is small, and adhesion therefore does not occur to any perceptible extent. But though this instrument may be good enough for practical use, Mr. Munro would hardly contend that its performance is equal to that of a carbon microphone.

In addition to this phenomenon of adhesion, and probably connected with it, are the facts that metallic contacts, unlike those of carbon, do not even approximately recover their original resistance when once it has been reduced by increased pressure or increased current, unless, indeed, complete separation occurs, and even the initial effect of pressure upon resistance is in general much more marked with carbon than with metals.

Lastly, there is the fact that, in the case of carbon, pressure and current act in consonance with each other; pressure diminishes the resistance, and in so doing increases the strength of the current, and the current thus strengthened effects a further diminution in the resistance. In the case of metals, on the other hand (or at least in the case of clean bismuth), pressure and current tend to produce opposite effects. The resistance is diminished by pressure, and the current consequently strengthened; but by reason of the increased strength of current the resistance is *higher* than it would have been if the current had remained unchanged. The effect of this antagonism is not very great, but it seems to give a material advantage to carbon.

In conclusion I think that the results arrived at in this paper may be made to furnish data for designing upon scientific principles a carbon pencil microphone which shall possess the maximum degree of efficiency; and, without entering into details or making any specific calculations, I propose to indicate briefly the lines which should, in my opinion, be followed in order to secure the most satisfactory results. The following questions present themselves for solution:—

(1.) Should the constituent elements of the microphone be few or many?

(2.) Should they be arranged in series or in multiple arc, or in a combination of the two?

(3.) Should they be light or heavy?

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(4.) Should the pressure at the points of contact be great or small?
(5.) Should the resistance of the system be high or low?
(6.) Should the current used be strong or weak?

Before considering the points here raised it may be well to state definitely what I conceive to be the *modus operandi* of the microphone as used for the transmission of speech.

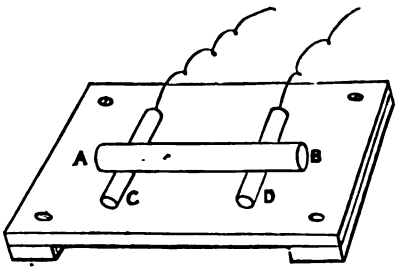

FIG. 9.

Fig. 9 is intended to represent a typical microphonic element. A horizontal carbon pencil, A B, is supported at the ends upon two carbon blocks, C D, which are attached firmly to a sound-board, usually of thin pine. The sound-board is acted upon by air waves, and caused to repeat upon a smaller scale the movements of the air particles which beat against it. It carries the lower carbon blocks with it in its movements, and causes them to press with varying force against the under side of the loose carbon pencil. The varying pressure produces alterations in the resistance at the points of contact, in exact correspondence with the phases of the sound waves, and the strength of a current passing through the system is thus regulated in such a manner as to fit it for reproducing the original sound in a telephone. The loudness of the repeated sound increases with the limits between which the current is made to vary.

Now, if it is true, as this theory supposes, that the whole action of the microphone is due to the motion, or tendency to move, of the lower carbon blocks (the influence of sonorous vibrations upon the loose block or pencil being so small as to be negligible), it follows that, if the variations of pressure are to be considerable, the upper block must be capable of offering resistance to the movements which the lower blocks tend to perform. It will, of course, do this the more effectively, the greater its inertia, and therefore its mass or weight. In order, therefore, to secure the greatest variations of *pressure*, the loose carbon must clearly be heavy.

But with the ordinary arrangement a heavy carbon implies great pressure at the points of contact; and it has been clearly proved that the resistance is far more easily varied when the average pressure is small than when it is great. Here, then, we have two conflicting requirements, and, if the usual arrangement is to be retained, a compromise must be effected, and it will be necessary to ascertain by experiment or calculation what must be the weight of the carbon in order that sonorous vibrations may produce the widest variations of current; remembering that if it is too light the differences of *pressure* will be small, and if too heavy the changes of pressure will give but small changes of *resistance*. But it would, I think, be decidedly better to depart from the usual form, the chief recommendation of which is its extreme simplicity. Many methods will suggest themselves of arranging the materials in such a manner that, while the weight of the loose carbons is great, they may exert but slight pressure against the fixed carbons. Fig. 10 illustrates an example of such

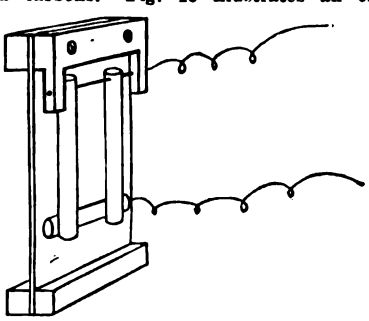

FIG. 10.

an arrangement. The loose carbons are suspended vertically upon a wire (attached to the frame of the instrument) which passes through holes in their upper extremities, their other ends resting lightly upon a horizontal pencil which is fixed to an upright sound-board. This may be mounted in a swing-frame like that of a looking-glass, and the pressure of the carbons adjusted by varying the inclination of the frame. Ordinary ingenuity will suggest other methods of accomplishing the same purpose.

The question as to whether it is preferable to arrange the elements in series or in multiple arc is very easily answered. If the elements are in series, the whole of the current used will pass through each of them; while if they are in multiple arc the current will be subdivided and each element will be traversed by a current the strength of which (supposing them all to be equal) will be inversely proportional to the number of elements. Now, the sensitiveness of the contacts to changes of pressure has been shown to increase greatly with small currents, and hence it follows that the multiple arc is to be preferred to the series system. The same reasoning, in a modified form, will condemn a system in which the series and multiple arc arrangements are combined; for the greatest perfection, therefore, the multiple arc system pure and simple should be adopted.

The high degree of sensitiveness attending the use of small currents points also to the advantage of multiplying the number of the elements. I believe that this number might well be made much greater than is customary, being limited only by considerations of space. The sound-board should not, of course, be too large, or there will be a risk of the sonorous waves reaching different parts of it in materially different phases, especially if their direction is oblique to the surface of the board. But it would not be difficult to arrange 50 or 60 such suspended elements as those shown in Fig. 11 within an area 15 centimetres square. I have made a transmitter upon this plan, in which the suspended elements, forty-five in number, consist of brass tubes filled with lead, and having short pieces of carbon fitted into their lower ends, and I believe its performance is greatly superior to that of most instruments of the kind.

Since the efficiency of a microphone depends principally upon its power of varying the strength of the current in a circuit comprising the microphone, a battery, and the primary wire of an induction coil, it is clear that the electromotive force of the battery should be as high as is consistent with other conditions, and the resistance of the battery coil and microphone should be low; for the proportional change of resistance caused by sonorous vibrations remaining the same, the stronger the maximum and minimum currents, the greater will be the actual difference between them. But for securing sensitiveness it is very important that the current passing through the microphone should not exceed a certain strength, and indeed, if the pressure is light (as it should be), a strong current will, as we have seen, enormously increase the resistance of the contacts, or some of them, thus impairing or utterly destroying the efficiency of the instrument.

The subjects of all the questions with which these observations were introduced have now been touched upon, though no attempt has been made to answer them very definitely. In general we may say that—

(1.) The constituent elements of a microphone should be numerous.
(2.) They should be arranged in multiple arc.
(3.) They should be heavy.
(4.) The pressure at the points of contact should be light.
(5.) The resistance of the microphonic system should depend upon the resistance of the rest of the circuit (which should be small) and upon its sensitiveness to changes of pressure. In general it should be small.
(6.) Up to a certain limit, depending upon the number of contacts and their pressures, the current used should be strong.

It need hardly be added, in conclusion, that the observations which I have ventured to offer do not profess to do more than indicate the merest outlines of the details which should be considered in designing a carbon pencil microphone of the greatest possible perfection.

MAXIM-WESTON ELECTRIC COMPANY (LIMITED).

The ordinary general meeting of the shareholders in this Company was held on the 20th inst., at the City Terminus Hotel, under the presidency of Admiral Sir Edward A. Inglefield, C.B., F.R.S.

The SECRETARY (Mr. Thomas R. Comyn) read the notice convening the meeting, and the report of the directors was taken as read. It stated, *inter alia*, that "The recent Electric Light Bill has not been of benefit to electric light companies (owing to vestries and corporations not yet being in a position to take advantage of its provisions), and other causes have tended to obstruct the use of electricity for lighting purposes. But the directors feel convinced that only further time is necessary to bring it into general use; and, meantime, most valuable improvements have been made in the lamps and dynamos, expenditure curtailed to the utmost, a number of agents appointed, and the Company put in a position to undertake the most extensive contracts immediately when obtained. As some evidence of this, it may be stated that contracts have recently been made with the Science and Art Department for the lighting of the Bethnal Green Museum, with Messrs. Kirk and Randall for the new dock works at Tilbury, with the proprietors of Astley's and the New Grand Theatres, independently of lesser lighting contracts. Several others of an extensive character are now pending, with every prospect of being satisfactorily completed. . . . An agreement has been concluded with an influential syndicate for conditional concessions for the various Australasian Colonies. The value of the stock, &c., at the factory and at the various centres of installation amounts to £21,372, and that of the lease, buildings, and furniture to £2,390. Everything is in a sound, workable state, and a most efficient staff has been organised, capable of undertaking any description of lighting, and at a cost for wages which will compare favourably with any other company. The present contracts for lighting Queen Victoria-street and Southwark Bridge, and for Pentonville-road, are in a satisfactory condition, and there is a probability of both being considerably enlarged on remunerative terms. The Company is now undertaking no unremunerative contracts. With additional capital, the directors see their way to a large and profitable business, and they have thought it desirable to submit for the consideration of the shareholders a proposal to increase the nominal capital of the Company to £500,000, to be issued as required. This will enable the directors to extend the Company's operations to the numerous towns and districts still unrepresented, and pave the way for concessions. They also propose to commence the manufacture of dynamos, which must prove a lucrative source of revenue."

The CHAIRMAN, in moving the adoption of the report and balance-sheet, said he had not the least doubt that during the meeting there would be so much discussion on every subject that perhaps if he were to enter into any lengthened statement as to the progress of the Company since their last meeting it might only result in repetition. He thought, however, he might outline what he had to say by simply stating that since the last meeting the directors had done their utmost to further the interests of the Company. They had met with considerable difficulties. The shareholders probably knew that the City lighting business had not been a successful matter in a commercial point of view, but that it had been successful as regarded proving the value of the light and of the Company's system he thought none of them could have the least doubt. The question had been frequently raised as to how it was that the Company, having had a good many orders, and apparently done a certain amount of business, had now arrived at the position of not having capital to carry on. He thought he had better state at once in a few words that that condition of affairs had resulted first of all from having an entirely new business to conduct; in their having taken over in the first instance a very extensive contract as part of the business of the Company, by which they had had a serious loss—he alluded to the City lighting; from having to pay to the promoter of the Company £70,000 before they could commence business; and in purchasing then the Lontin system without any incandescent system, in which respect they were in a position different from that of any other company which had obtained both arc and incandescent systems. However, finding themselves without

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an incandescent lamp they were offered for a very large sum the purchase of the Maxim and Weston patents. They might ask, Why did you not purchase the Maxim, having an arc lamp, and not acquire the Weston? The answer was, Simply because they were to be bought together or not at all. They, however, brought the price down to about half. Though the directors had the power to close with that purchase without consulting the shareholders they thought it better to do so, and they might remember that they at once gave their consent, though the directors hinted that, having to pay £52,000 out of what they thought was working capital, it might possibly be necessary to increase the capital. He, however, also held out to them hopes that by selling their patents to subsidiary companies they might obtain, as in the case of another large company, sufficient money not only to carry on the business but to declare dividends and do as other companies had done, work successfully without raising further capital. He might remind them that out of the forty-four companies formed thirty-four had a larger capital than this Company had at starting, and perhaps the greatest mistake they had made was in not having a larger nominal capital on forming the Company. However, taking things as they were they found themselves, having paid £70,000 in the way of purchasing patents which they did not now use, of installing the City lighting, and of purchasing a new incandescent and arc system—they found themselves with very little money to carry on with, and yet so far they had succeeded in going on without getting into debt. The failure in connection with the subsidiary companies was due to two or three reasons. One was because they adopted the customary plan of using promoters, who were interested in the parent Company, and who undertook, on certain terms, to bring out a subsidiary company. He was not for one moment going to condemn the system of promoters, as it was almost essential in bringing out companies that there should be promoters. There were many things which had to be done only through a promoter. A promoter had to lay out a large sum of money of his own, which he must expend to bring out a company, and if it did not float he himself had to pay. It was, therefore, very natural that he should be protected against such an event. First, they started an Australian Company, but, owing to difficulties, that company never floated. Everything was done on the part of the Board, and every point they thought fair was agreed to. That company, however, did not float. An Indian Company fell through very much in the same way. At last the company which had floated was formed by the parent Company, and carried out by two of the directors. For that reason he, as chairman of this Company, was also a director of the Lancashire Company — a point which had sometimes been referred to as an extraordinary thing. That company had been floated, and had paid a large sum of money to the parent Company, and if all the calls which were due were paid, as they ought to have been by now, the parent Company would have had some £3,000 or £4,000 more than it had had. They had done their utmost by the means he proposed before—by subsidiary companies—to prevent the possibility of a call. These were matters which, perhaps, ought to be dealt with at the special meeting which had been called to follow the ordinary meeting. Referring more to what had been done in the past, he had in his hand a list of the contracts, exhibitions, &c., made by the Company, and a list showing what their sales and contracts had been, and what they had expended on exhibitions. A very pertinent question was sometimes put to him by shareholders. How, when you have spent this large sum and have not made a profit, do you expect to make a profit out of fresh money? Up to the date of October, 1882, they made sales amounting to £6,776, with a clear profit on that of £1,666. These were sales of their lamps, dynamos, and apparatus—sales which had been carried through. They had had some contracts, and they would understand that these early contracts were more or less competitive, the lowest price being taken. They had had a great deal of this kind of opposition to contend with. They took a certain amount of contracts as low as they could. There was the Metropolitan Railway—a contract for which had been undertaken before this Company was formed. That, however, was part of the terms on which the shareholders subscribed their money. On that they made a loss of £1,225. Then there was the Edinburgh Post Office. At that installation they put up an engine powerful enough to do three times the amount of the work, and it was not necessary for him to explain to them that the engine and people that had to work a dynamo were just as expensive for three lights as for 300, barring the expense of coal and carbons. They provided there in the expectation of having a larger number of lamps to supply, and they made a loss of £380. The moment they could withdraw from that work they did so. They thought it well at a certain sum to take a contract for lighting the Botanic Gardens. There they had a loss of £26, while at Reading they also made a loss of £26. On the City lighting—which was also a contract on which the shareholders subscribed their money, and on which the reputation of their light had been very much sustained—they had made a loss of £4,405. That sounded bad, but how did it come about? They started with a new company. The shareholders might say, Why did you not take advantage of what you might have learnt from the Brush and other companies? Those companies, however, did not give information to their rivals, and they had found that those companies also had been unsuccessful with their cables. They in this Company had had to lay their cables two or three times. Their great loss on the City lighting had been owing to the cables and the difficulty of getting them properly to carry the electricity from the other side of the river. However, the loss there was certain loss, by which they had gained a certain amount of experience, and though they were pressed now to take another contract for the city, they might depend upon it that if it were taken it would be at a profit. At the last meeting it was said that they had not exhibited, and they replied that they could not afford to do so. They had spent no less than £1,347 for the Crystal Palace Exhibition; at Warwick House, Regent-street, £170; at the Guildhall, £160; and at the Albert Hall, £50. These were exhibitions. At the Opera House, too, there was an instaliation before this Company came into existence, and there was an expenditure of £128. Altogether £1,868 had been spent on exhibitions, and that, added to the loss of £6,064, was a very considerable item. Having, however, got all the advantage they could by the exhibitions, they had declined to exhibit any more. Some people had said "Why do you not exhibit at the Aquarium?" and they had replied, "Because we will not exhibit any more without being paid." Those were the grounds on which he thought, having paid for their experience very largely, and having plenty of contracts actually before them, and plenty more in view, and knowing exactly what they could do electric lighting for, they would be justified in asking them to carry on the Company, which he believed would yet be a great success. At the special meeting they would be able to deal with this matter, and the proposed increase of the capital.

Sir HERBERT BRUCE SANDFORD, in seconding the motion, stated that of the sum of £14,456, which figured in the balance-sheet under the head of debtors, £10,000 was due by the Lancashire Company when they had allotted more of their shares. The amount was not all due at once. The sum of £16,302 appeared as expenditure for the year, but there was £3,190 in that amount for depreciation of stock, which did not appear in the first year's expenses. There had also been an increase as compared with the previous year of £650 in the legal expenses. These two items, therefore, accounted for £4,848 of the £16,302.

Mr. TALLERMAN, at some length, complained of objection having been taken to his continued sitting on the committee which had been appointed to go into the Company's affairs.

The CHAIRMAN stated that Mr. Tallerman had not been appointed a member of the committee at the meeting of shareholders, and he therefore really thought that those who had objected, in face of that fact, to the continued sitting on the committee if Mr. Tallerman were not to blame [hear, hear]. In further reply to Mr. Tallerman, the chairman added that the British Indian Company was never floated, through the absence of the promoter, who would have helped it to float.

Mr. TALLERMAN then complained of the losses which had been made by the contracts and the purchase of patents now obsolete. However, the Company was possessed of two of the best patents, used most extensively in America, and what had they done with them? He went on to contend that the Lancashire Company had become possessed of one of the only good assets which this Company had. He also complained of the large amount which was expended in starting the Company.

After some discussion of a somewhat personal and recriminatory character,

Mr. WILLIAM ABBOTT said the shareholders ought to sink all personal differences, and proceed with the business for which they were called together. The first business was the passing of the accounts and the election of directors. If they did not pass the accounts they would not be showing much confidence in the Board; if they passed the accounts they would exonerate the directors. He did not know what were the qualifications of the managing director, but he must say he was grievously disappointed at the outcome of the business for the carrying on of which the Company was established. They seemed to have expended about £172,000 without any result to the shareholders in the way of dividend; and, under these circumstances, it did seem strange to him that the directors should come before the shareholders and ask them to water the capital by raising it to £500,000 without holding out a prospect of more successful results than in the past. Of course they must make some allowance for the rampant speculation which had taken place in the shares of electric lighting companies. He did not think that any of these companies, not even the celebrated Brush Company, had been so successful as was anticipated. It was for the shareholders to consider whether they would retain the present directors on the Board or whether they would strengthen the Board by men of experience. It was a business which required constant application and attention.

The CHAIRMAN, in reply to observations, proceeded to justify the action of the Company in bringing out the Lancashire Company. Mr. Watt, who had a large connection in Liverpool, succeeded, working with Mr. Thompson, an engineer, so far in establishing this Company's system in Liverpool, that two other companies who tried to light the district left, and this Company's system was the only system of electric lighting now going on in Liverpool. Mr. Watt asked nothing for his trouble and labour, whilst other promoters asked very large sums; but on looking over the Articles of Association the directors found they were at liberty to remunerate any officer for special service, and therefore they decided they would give Mr. Watt his qualification in the Lancashire Company, namely, 200 shares, which, however, had not been given. The Lancashire Company was floated, and it was not the directors' fault that they did not obtain the capital required, and therefore that the Lancashire Company was unable to pay the parent Company. As regarded Mr. Tallerman's interest in the Company, that gentleman had asked the directors for the concession for the Australian Colonies for himself and a syndicate.

Mr. HUGH WATT (managing director) denied that he had ever refused to give information to any shareholder. He joined the Board as one of the largest shareholders at the request of Sir Herbert Sandford. He had never received a farthing for carrying through the Liverpool Company. As regarded the expenses they compared favourably with those of the previous year, having been £16,300 last year against £16,480 in the previous year, and he might mention that a considerable portion of the expenses included in last year's accounts were incurred in the previous year. For the last three months the expenditure had been about £2,000. The profits for the last three months had been £1,400, whilst the profits for the previous eight months had been only about £200. With regard to the manufacture of lamps, when he joined the Board the Maxims were costing 17s. 6d. per lamp; they were now costing 2s. 6d. per lamp. The Weston lamps when he joined were costing £7 per lamp; they were now costing only £3. They would be able to pay expenses out of the Weston lamp alone.

Mr. DODSON and one or two other gentlemen addressed the meeting, chiefly on their personal dealings with the Company.

The report of the committee was then read. The committee expressed the opinion that the Company possessed a property which should become valuable; at the same time, they came upon much which they must unequivocally condemn. They considered that a large sum had been frittered away. For the success of the Company money was absolutely necessary, and the prospects of the business were such that the committee had no hesitation in recommending the shareholders to find the money; but there must be a great change of management. If the shareholders would not find the money several friends were prepared to find it.

The CHAIRMAN said that before proceeding further it was necessary to decide whether or not the shareholders would accept the accounts. He strongly objected to the expression in the committee's report that a large sum had been "frittered away."

The resolution for the adoption of the accounts was then put and rejected.

A suggestion was made that the meeting should be adjourned for a fortnight, in order to give time for the shareholders to consider the statements

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made in the report of the committee, and also whether new directors should be appointed.

Eventually the meeting was adjourned for a fortnight, at the same time and place. The business of the special meeting was also adjourned.

REUTER'S TELEGRAM COMPANY, LIMITED.

The annual general meeting of this Company was held on the 25th inst., at the offices, Old Jewry, under the presidency of Colonel James Holland.

The SECRETARY having read the notice convening the meeting, the report of the directors was taken as read.

The CHAIRMAN then said: The second paragraph of the report, gentlemen, explains the main cause of the deficiency of profits in the past year. Our worthy secretary has just noted that this is our nineteenth ordinary general meeting, and it is, I regret to say—or rather I am glad to say it, in one sense—the only meeting at which we have had so sorry an account to show to the shareholders. The main cause of this has been the Egyptian war. So much interest was naturally taken in that war—people took such a deep interest in it—that we felt bound to have frequent and full reports of what was going on. Not only had we daily, but on many occasions hourly reports, and I think that those who bear in mind the telegraphic intelligence supplied from the seat of the war during that time will bear me out in saying that nothing could be more full, complete, or correct than the information we conveyed. But gentlemen, war is an expensive matter not only to the Government but to those whose duty it is, as in our case, to convey intelligence to the public, for we have to pay heavily for every telegram we receive and send. We, however, felt it our imperative duty, as we always must feel on occasions of interest and importance to the country, that the intelligence should be full and correct, at whatever cost, for it is the very life blood of the Company that we should be the first in the field—first and most correct. We state in the report that the telegrams alone from Egypt cost us over £3,000 more than the ordinary amount disbursed. Besides that we had to pay fully £1,000 more in the payment of special correspondents and agents engaged on our behalf to furnish the intelligence; and there were other minor charges affecting our establishment which also cost more than usual. We also had in addition to that great war in Egypt a small war of our own in South Africa, where an endeavour was made to compete with us in the furnishing of information. I have just intimated that we cannot be laggards in the race for supplying intelligence. We had to put that competition down, and we succeeded, but again the cost added very much to the other charges I have alluded to. It was very much to be regretted, but we look on these matters, and occasional heavy losses of this kind, very much as the directors of a life or fire insurance company would do. It is an actual necessity that there should be loss of life and losses involved by fire, otherwise these companies would not exist; but there will be years when extraordinary losses will come on life and fire insurance companies, and they find themselves heavily hit. The past year has been one of those years with us. There was another item that swelled the general charges. Our worthy secretary was employed on a tour of inspection in India. This was very laborious, and the travelling charges were very heavy. It was, however, a purely exceptional case, not likely to occur again for years. He did very good service, but travelling in India is a matter that cannot be done for nothing. All or most of these charges are exceptional. Unless we have fresh wars, or agitations, we may expect in future years that we shall recur to our normal state. I have mentioned—and I think without blinking in the least—the various causes which have led to the somewhat unpleasant balance-sheet before you. At the same time there is always more or less of a silver lining to every cloud, and if you refer to the figured statement you will find that the subscriptions and commissions for the year have increased by about £900, showing that our business is by no means falling off—that while the expenditure is exceptional, the source from which future profits may be drawn is progressing in a very satisfactory manner. I may also mention that the sum taken from the reserve fund to give 5 per cent. dividend is not quite so heavy as would appear on the face of the statement. We there state that £2,500 has been taken from the reserve fund. It is quite true that we did that, but in accordance with the policy we declared when we purchased the freehold of this property we have carried every year since—and we intend to do so in future—£550 in the name of rent, as it were, to the reserve fund. We did that on the present occasion, and if you deduct that amount from the £2,500 we have taken from the reserve fund, you will find that we have really withdrawn somewhat less than £2,000. As to the general figured statement, the only other matters of interest remaining to be alluded to are sundry debtors and creditors, about £15,000 on each side. All of those have fairly run off. There is nothing in them to occasion the slightest anxiety. Those against us have all been paid off, and those for us are either paid, or there are some balances in the hands of agents. To the best of our knowledge and belief we have not a single bad account. I have now given you a full and fair account of the causes which have led to the present balance-sheet being unsatisfactory, and I have only to move—"That the report and balance-sheet now presented be received, adopted, and entered upon the minutes."

Admiral Sir John C. D. HAY, Bart., M.P., having seconded the motion, it was carried unanimously.

The CHAIRMAN then moved the re-election of Admiral Sir John Hay to his seat at the Board.

Mr. STOPFORD seconded the motion, which was carried unanimously.

The retiring auditors, Messrs. Quilter, Ball, and Co., having been re-appointed,

General J. F. M. BROWNE moved, and Mr. KEENLYSIDE seconded, a vote of thanks to the chairman and directors for their services in the past year. The motion was carried unanimously.

The CHAIRMAN, in acknowledging the compliment, expressed a hope that the next meeting of the Company would be held under more favourable circumstances.

The proceedings then terminated.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The directors will submit the following report and accounts of the above Company for the half year ended 31st December, 1882, at the nineteenth half-yearly general meeting, to be held on the 4th May, 1883. The revenue for this period amounted to £88,408 18s.; and the working expenses (including £2,146 9s. 9d. for repairs of cable) to £14,971 5s. 2d. After providing £1,311 17s. for income-tax there remains a balance of £72,125 15s. 10d.; to this is added £1,295 4s. 4d., brought forward from 30th June last, making a total of £73,421 0s. 2d. First and second interim dividends amounting to £39,000 have been paid, and £25,000 transferred to the reserve fund, leaving the sum of £9,421 0s. 2d. to be carried to the next account. The serious fault in the Lisbon-Madeira section, referred to in the last report, was removed on the 31st October, 1882; it had evidently been caused by the breaking of the wires by a ship's anchor; the fresh cable spliced in is now in closer proximity to shallow water, therefore less liable to be injured by vessels anchoring. The new cable between Lisbon and Madeira was successfully completed on the 19th October, 1882, by the Telegraph Construction and Maintenance Company, thus duplicating the first section of this Company's system. All the Company's cables are in good working order. The directors have appointed Mr. Carlos Frederico Taylor their representative in Brazil, in accordance with Article 27 of the Concession.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES APRIL 25.		BUSINESS DONE WEEK ENDING APRIL 25. Highest.	Lowest.
Anglo American	51,	52	51⅛	51⅛
Do. Preferred	83,	84	84	83⅞
Do. Deferred	20½,	21	21⅛	20⅞
Brazil Submarine	12⅜,	12⅝	12⅝	12⅜
Cuba	10,	10½	—	—
Do. Preference	17,	18	—	—
Direct Spanish	5⅛,	5⅜	5⅜	5⅜
Do. Preference	16,	16⅛	16⅛	16⅛
Direct United States Cable	12⅛,	13⅛	13⅛	12 13-16
Eastern Telegraph	10⅞,	11	11	10⅞
Do. 6 per Cent. Preference	13⅛,	13⅜	13⅜	13⅜
Do. 5 per Cent. Debentures, 1899	104,	107	—	—
Eastern Extension	12⅛,	12⅛	12⅛	12 3-16
German Union	9⅞,	10⅛	10⅛	10⅛
Globe Telegraph and Trust Company.	7,	7⅛	7⅛	7
Do. Preference	12⅛,	13⅛	13⅛	12⅛
Great Northern	13⅛,	13⅜	13⅜	13 1-16
Indo-European	33,	34	—	—
Mediterranean Extension	2,	2⅛	1⅛	1⅛
Do. Preference	6,	7	6⅛	6⅛
Reuter's	9⅞,	10⅛	—	—
Submarine	247,	252	250	247½
West India and Panama	1⅛,	1⅛	1⅛	1⅛
Do. 1st Preference	7⅞,	8⅛	8⅛	8
Western Brazilian	7⅛,	7⅞	7 7-16	7 3-16
West. Union 7 per Cent. 1st Mortgage	125,	128	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	105	104⅛

TELEPHONES.

Consol. Telephone and Maintenance	⅛,	1	⅛	13-16
Oriental	⅛,	⅛	11-16	11-16
United Telephone	10,	10⅛	10⅛	10

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	5⅛,	5⅛	5 15-16	5⅛
Do. (fully paid)	7⅛,	8⅛	8⅛	8
Hammond Light	2⅞,	3⅛	3⅛	2⅞
Eastern Electric (fully paid)	—,	—	—	—
Pilsen, Joel, and General Electric	⅛,	⅛	⅛	⅛
Swan	1⅞,	2⅛	2	2
Maxim-Weston	⅛,	⅛	⅛	3-16

FACTORY and WATERSIDE PREMISES to be LET, or the LEASE, at £200 per annum rent, to be SOLD. First class premises, with a frontage of about 40ft. to the canal, and 40ft. on the other side to the road. Depth about 90ft., ground floor of factory, with two floors above, 18ft. by 85ft. Steam power on the premises, to be taken at a valuation. Situate close to King's Cross. Apply to the SECRETARY of the London General Cab Company, 68, York-road, King's Cross, N.

EMPLOYMENT WANTED in LONDON upon Dynamo Machines by an Electrical Student. Payment no object.—Address W., 21, Herbert-street, New North-road, N.

TO TELEGRAPH and GENERAL ELECTRIC ENGINEERS.—GOOD FIRM WANTING an intelligent, specially-educated PUPIL. Write, with terms and particulars, STANLEY, Wellow, Bath.

TELEPHONES.—Advertiser wants to purchase or arrange for working on terms in Australasian Colonies a good instrument clearing the Bell and Edison patents.

Address ELECTRICIAN, care of J. G. Dalzell, Esq., Solicitor, 29, Essex-street, Strand.

THE ADVERTISER wishes to know if there is as yet any Company which undertakes the LIGHTING of PRIVATE HOUSES with Swan lamps by means of a regular supply of ready-charged accumulators.—Postal address, S. H. S., Junior Carlton Club, Pall-mall.

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SLIP

ELECTRIC LIGHTING AT NORWICH.—The experimental lighting of certain parts of Norwich by electric lamps is to be discontinued for the present.

ELECTRIC LIGHTING AND THE ISLINGTON VESTRY.—This Vestry have resolved to call in an "expert" to advise them in electric lighting matters.

RESIGNATIONS.—It is stated that Mr. Cordner, general manager, and Mr. Allen, chief electrician, of the Anglo-American Brush Company have resigned their respective posts.

SOUTH AFRICAN CABLE AGAIN INTERRUPTED.—The Eastern Telegraph Company announce that the Eastern and South African Telegraph Company's Mozambique-Zanzibar cable is again interrupted.

ELECTRIC LIGHTING FOR SYDENHAM.—The Brush Company have applied to the Lewisham Board of Works for permission to light a portion of Sydenham near Kirkdale. The Board have referred the matter to their Works Committee.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.—It is notified by the Telegraph Construction and Maintenance Company (Limited) that a distribution of 1s. per £5 certificate will be made on the certificates issued under the Trust Deed of 1875.

ELECTRIC LIGHTING IN THEATRES.—The Société Electrique Edison, of Paris, have, we are informed by our Austrian correspondent, got an order to light the new National Theatre at Prague by their system. About 1,700 A (16 candle-power) lamps will be required.

LONDON AND GLOBE TELEPHONE COMPANY.—This company announce the establishment of a Metropolitan Telephone Exchange, the subscription being £10 10s. per annum. They also intend fixing automatic fire alarms in warehouses and private houses.

THE BRUSH SYSTEM IN MEXICO.—It is stated that arrangements have been made with the authorities in the city of Mexico to light the town and its suburbs on the Brush system by a private company formed for that purpose by influential houses in London and Mexico.

THE TELEPHONE IN THE PROVINCES.—A provincial paper says that Messrs. J. and W. Maxwell and Sons, of the Silloth Chemical and Manure Works, are about to establish telephonic communication between the works and their office in Carlisle. The wire will be fitted on the existing telegraph posts..

COUPON DUE.—The Eastern Extension, Australasia, and China Telegraph Company (Limited) have given notice that the coupon on their Five per Cent. Manila Debentures, due on the 1st inst., will be paid at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons should be left three clear days for examination.

ELECTRIC LIGHTING AT LEEDS.—The Town Council, at their meeting on Wednesday, voted a sum of £10,000 for the purpose of applying the electric light to the Town Hall, the new municipal offices, and a few of the principal streets in the borough, preparatory to the general application of the light if the experiment proves satisfactory.

WRECK OF A CABLE STEAMER.—A Lloyd's telegram received from New York states that the steamer Professor Morse, 1,023 tons, employed in telegraph cable laying, whilst on a voyage from New York to Boston, ran ashore on Block Island, Rhode Island, and is full of water. The vessel has been abandoned, it being found impossible to save her.

CUBA SUBMARINE TELEGRAPH COMPANY.—The number of messages passing over the lines of this company during the month of April was 4,411, estimated to produce £3,900, against 3,937 messages, producing £3,921, in the corresponding month of last year. The traffic receipts for the month of January, estimated at £2,800, realised £2,829.

AN ELECTRIC RAILWAY AT WIMBLEDON.—The National Rifle Association have entered into a contract with the Electric Motor Syndicate to lay down an electric railway at Wimbledon on their improved system, and to work it during the meeting of the association in July next. The train will consist of six carriages, carrying twenty-four passengers each.

ELECTRICITY AS A MOTIVE POWER.—This was the title of an interesting paper by Professor George Forbes, which was read at a meeting of the Society of Arts on Wednesday last, Mr. W. H. Preece occupying the chair. We regret that the amount of matter awaiting insertion in the two last numbers of the present volume will necessitate our keeping Professor Forbes's paper for the first number of Vol. XI.

ELECTRIC LIGHTING IN BRUNN (AUSTRIA).—The Edison Company are going to light up a second factory in Brünn by their system. Some 250 lamps will be used. We learn that the lamp factory started in this town by Mr. Francis Jehl is so far ready for work that the first Edison lamp was completed a few days ago. The lamps on the stage of the theatre have now burnt for over 1,500 hours since the opening ceremony.

SOCIETY OF TELEGRAPH ENGINEERS.—At the meeting of the society to be held at 25, Great George-street, at 8 p.m. on Thursday, the 10th May, the following papers will be read:—"The Electric Holophote Course Indicator, for the Prevention of Collision at Sea," by J. H. A. MacDonald, Q.C., Associate; "Electro-Motors and their Government," by Professors W. E. Ayrton, F.R.S., and John Perry, Members.

THREATENING A POSTAL TELEGRAPH OFFICER.—At the Guildhall, on Wednesday, James Bastaple, of Hart-street, Covent-garden, W.C., was committed for trial for sending a letter to Mr. Fleetwood, inspector of underground telegraph wires, in which he threatened to kill both the inspector and a foreman of works. It appeared that the prisoner had been dismissed the service by Mr. Fleetwood, and that he considered his dismissal was due to the foreman of works.

ELECTRIC LIGHTING AT CHESTERFIELD.—At a recent meeting of the Chesterfield and Derbyshire Engineers, held at Chesterfield, two papers on electric lighting were contributed. In the course of a discussion on one of these papers a member remarked that he "nearly fell over the lamps (now in use at Chesterfield) in trying to find them," from which it is to be presumed either that the gentleman in question is remarkably shortsighted or that the lamps do not give much light.

DUBLIN TELEGRAPH CLERKS.—In the House of Commons on Thursday week Mr. O'Donnell asked the Postmaster-General why the female telegraph clerks at Dublin, receiving 30s. a week and upwards, were refused the annual holiday of three weeks enjoyed by female telegraph clerks receiving similar rates of salary in London. Mr. Fawcett replied that the difference between the annual periods of leave in London and in Dublin appeared to him to be an anomaly, and that he would see whether steps could not be taken with a view to its removal.

TO BE WOUND UP.—The petition for the winding-up of the Electric Light Syndicate was heard by Mr. Justice Fry on the 20th April, and an order for winding-up made.—The Scandinavian Electric Company, of 20, Bucklersbury, E.C.,

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is to be wound up, voluntarily.—The Plating Company, of 34, Kirby-street, Hatton-garden, E.C., is also to be wound up voluntarily.—A petition for the winding-up of the British and Irish Telephone and Electric Works Company, presented by John Gaskell, a creditor, is to be heard before Mr. Justice Pearson on the 11th instant.

The Vienna Exhibition.—We are informed that the organising committee of this exhibition have made arrangements with Herr A. Hartleben, publisher, of Vienna, to collect for them as many works dealing with electricity and its applications as possible, also all the periodicals of the day connected with electrical science and practice. These will be exhibited in a special room, where they can be consulted free. In fact, a reading room will be provided, the contents of which will be of an international character. Electric lights only will be used in this room.

Chess-playing by Telephone.—Several games of chess have lately been played in provincial towns, notably Leeds and Bradford, in which the moves were announced to the respective players by means of the telephone, the players occupying different houses at some distance from each other. The latest example of this mode of chess-playing took place at Scarborough a few days since, between two shops belonging to Messrs. F. Wallis and Son, in Newborough and South street respectively. The instruments used were the Gower-Bell, the line having been put up for Messrs. Wallis by the Post Office officials.

The Model Provisional Order.—In the House of Commons, on Friday week, Mr. Chamberlain told Mr. Yorke that several local authorities in the metropolis were anxious for an extension of time for considering the Model Provisional Order of the Board of Trade; but he found that any such extension, if granted, would render the provisional order impossible during the present Session, owing to the Standing Orders of the other House. Many of the principal authorities in London and the country had already come to a satisfactory arrangement, and, in his opinion, all of the bodies had had ample time for the consideration of the subject.

Electric Lighting and the Board of Trade.—The Greenock Town Council sent a deputation to wait upon Mr. Chamberlain the other day to urge the necessity of amending the permissive powers of local authorities as to electric lighting, or, at all events, to extend the time allowed for experiments within a compulsory area from two to five years. Mr. Chamberlain being otherwise engaged when the deputation called at the Board of Trade, they saw Mr. T. H. Farrer, permanent secretary. This gentleman promised that the matter should receive attention, but did not think that there was any hope of the period during which experiments could be made being extended.

Charing-cross Electric Railway.—When the Select Committee of the House of Commons, presided over by Admiral Egerton, met on Tuesday, for the purpose of inquiring into the merits of the Charing-cross and Waterloo Electric Railway Bill, it was announced, on behalf of the promoters, that it was their intention to withdraw the Bill for the present Session. The withdrawal of this Bill will not, however, interfere with the construction of the first section of the above line, viz., that between Charing-cross and Waterloo. The Bill which has been withdrawn related to the extension from Waterloo to the neighbourhood of Queen-street, crossing under the Thames again at Bankside.

Electric Lighting in the Holborn District.—At the last meeting of the Holborn District Board of Works a report was received from the Board's Committee of Works reporting on the application of the Metropolitan Brush Company, and recommending, after conferring with the representatives of the company, that on the company including the parish of St. Sepulchre, Middlesex, within schedule A of the area of supply, also furnishing a map showing the whole of such area, and appropriating a sum of not less than £15,000 as a capital, the provisional order be agreed upon in the model form settled by the Board of Trade. A letter was also received from the company, confirming the agreement come to with the committee as to including St. Sepulchre in schedule A and the remainder of the district in schedule B. The committee's report was adopted.

Joint Stock Companies.—According to a notice in the *London Gazette* for May 1 the undermentioned have been struck off the Register of Joint Stock Companies:—Allan's Trans-Atlantic Telegraph Company, Economic Telegraph Company, Finsbury Telegraph Newspaper Company, Great Northern Electric Light Company, Oriental Telegraph Company. The following will be struck off the register at the end of three months from May 1, unless cause is shown to the contrary:—Anglo-Danish and Russian Telegraph Company, Anglo-Indian Telegraph Company, Danish, Norwegian, English Telegraph Company, Direct English, Indian, and Australian Submarine Telegraph Company, Electro-Protector Boiler Company, Franco-American Telegraph Company, Provincial and Foreign Telegraphic News Company, Telegraph Works Company, West Indian and American Telegraph Company.

Sixpenny Telegrams.—In the House of Commons on Thursday week Mr. Dawnay asked the Postmaster-General, in view of the proposed alteration with regard to 6d. rates for telegrams, an alteration which it is computed will entail a loss of £170,000 a year, what arrangements would be made in the case of the rural post offices, where contracts had been signed under which the shillings at present paid in for telegrams were allowed to the guarantors of the annual sum paid to the Post Office Department; and whether the guarantors of such sums would be secured from any share in the loss which it was calculated would be entailed on the revenues of the Department by the change in the telegraphic rates. Mr. Fawcett replied that he thought it would be only fair that guarantors should not suffer any pecuniary loss from the proposed reduction of telegraphic charges, and they would not, therefore, be called upon to pay any more than the payment made in the last year or the average payment of the three last years.

Gas in Paris.—Paris and its light purveyors have been quarrelling. "Paris is threatened with a plague of darkness," telegraphed the correspondent of a daily paper a day or two ago, and continued, "The misunderstanding between the city authorities and the gas company has reached such a pitch that the latter declares, unless the old price of 15c. per cubic metre be maintained, it will cut off the supply on Friday next (May 4). A Prefectoral decree of March 22 enjoined the company to reduce the price of gas for lighting the city from 15c. to 12½c., and of that supplied to private consumers from 30c. to 25c. The company denied the right of the Municipal Council to order a reduction in the price, and instituted legal proceedings against the city, which have not yet been brought before a court of law. Pending a decision, private individuals will continue to pay the old price, but the city government adheres to its intention of only paying 1¼d. instead of 1½d. Unless, therefore, the company give way, it will close the meters on Friday, and the gasworks will, in accordance with a clause in the agreement, be taken over by the city. As so important a transfer can, however, scarcely

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be effected in a day, there is a possibility that Paris, during Friday night at least, will be plunged into utter darkness, to the delight of malefactors generally, and terror of honest folk. Such are the benefits of huge monopolies."

Long Distance Telephone Company.—The prospectus of a company that has been formed under this title has appeared in the advertisement columns of the daily papers for the last few days. The capital is put at £600,000. The company will work the patents of Mr. Hopkins, an American electrician. Before subscribing to this company it would be well to ask the promoters, "Have you a license from the Postmaster-General?" The answer to this question should be insisted on, as without such a license all the patents in the world are no use, for the simple reason that they cannot be used. The prospectus gives elaborate estimates for the erection of trunk lines to Liverpool, Manchester, and other large towns. Now, seeing that the Postmaster-General alone has the power to erect such lines, it is taking time a little too forcibly by the forelock to publish estimates like those above-mentioned before obtaining a license from the Postmaster-General. We notice that the United Telephone Company have challenged the validity of the Hopkins patents, and it seems likely that the saying, "Who buys a telephone, buys a lawsuit," will be exemplified should the company get their money and endeavour to sell their telephones. We have given our opinion upon the long distance trials in America in a previous note. Since writing the above, we notice that the United Telephone Company have proceeded against the Long Distance Company, and that Mr. Justice Chitty gave leave to serve a short notice of motion for an injunction on Friday.

The Brush System in Aberdeen.—The experimental lighting on the Brush system has come to an end, and the following report on the cost, &c., given in by the Gas and Lighting Committee of the Town Council:—"We beg to report that the time granted by the town council for the experiment in electric lighting presently being carried out by the council is now expired. The experiment was commenced on the 23rd day of December last, and has been carried on with little or no interruption since. Everything in connection with the experiment has been as economically carried out as possible, and the cost of the whole will be as follows: The construction of plant, including the sum of £60 for taking down the apparatus and reconstructing the buildings, will be £186 14s. 9d.; maintenance and wages, including the Brush Company's charge for sixteen arc lamps, each burning on an average six hours and a half per day for 121 days, at 1¼d. per lamp per hour, £222 19s. 3d. Total, £409 14s. The amount arising from a number of the gas lamps not being lighted, as per a report from the Inspector of Lighting, is £34 11s.; reducing the maintenance to £188 8s. 3d., and the whole expenditure in connection with the experiment to £375 3s. The sixteen electric arc lamps took the place of one Sugg lamp, consuming thirty cubic feet per hour; two Bray lamps, each burning fourteen cubic feet per hour; one Wigham lamp, burning twenty cubic feet per hour; and 102 ordinary lamps, each consuming two cubic feet per hour. To light the area with the electric light cost £222 19s. 3d.; ditto with gas, £34 11s.; or about six and half times more by electricity. The committee instructed Mr. Smith to take down and return the apparatus."

The Telephone in Brooklyn (New York).—In no place probably has the use of the telephone become more general than in Brooklyn. The business is now under the control of the Long Island Telephone Company, which has done as much during the past six or eight months as it did during all the previous period of its existence. The large and rapid increase of wires on our principal thoroughfares has marked the progress made in the extension of the service. "We have doubled our subscription list since last July," said General Superintendent W. D. Sargent the other day. "We then had 800 subscribers; we now have 1,600. We have extended our lines to Flushing, College Point, Whitestone, and Bayside. We are building lines to Jamaica, Far Rockaway, Hempstead, Babylon, and Patchogue, and we expect ultimately, probably during the summer season, to reach to the other end of the island. We have opened a pay station at Coney Island and will have stations in all the leading hotels on the beach. In the city we have rebuilt lines with first class poles, notably on Washington-street, and in the past six months have added between 500 and 600 miles of wire. About 5,000 messages pass over the wires daily in this city, and between Brooklyn and New York the number is some 30,000 a month. We have established a connection with Fire Department Head-quarters in Jay-street, so that an alarm of fire in the house or business place of any of our subscribers can be sent at once to head-quarters. We have sent many such alarms, and Commissioner Partridge in his late quarterly report to the Mayor bears testimony to the value of this arrangement. So you see we are making rapid progress. A great change has taken place since the latter part of 1881, when the company had only 101 instruments in use."—*Brooklyn Daily Eagle.*

The Bursting of Armatures.—The bursting of the armature of a dynamo, as recently reported in the daily papers, has caused much comment as to the possible danger arising from accidents of this kind, and, as usual, conclusions have been arrived at without any inquiry being made as to the facts of the case. Knowing that there is danger from flying fragments when a rapidly revolving mass is disrupted, and recalling the damage done by flywheels and grindstones, the writers guess that the effects produced by armatures acting similarly would be equally disastrous. In some classes of dynamos the armature consists of a shaft, upon which are placed many hundreds of discs of iron separated by paper, and around which coils of copper wire are wound longitudinally. Upon revolving this the centrifugal force tends to throw the copper wire off, but to hold it in place strands of spring brass wire or piano wire are bound at intervals about it. These confining bands have to resist the weight of copper only, the tensile strength of the discs being ample so far as they are concerned. Taking the diameter of the armature as twelve inches, and the speed as 1,000 revolutions per minute, each pound on the circumference would exert a force of about 169 pounds. The aggregate number of pounds of copper on the surface would cause a strain to be resisted by the combined strength of the copper wire itself and the confining bands. The difference is sufficient for a large margin of safety. When the armature is made of cast iron the tensile strength of the iron will resist the centrifugal force if the casting be without flaw, and the high degree of perfection to which casting is brought at the present time makes this aspect of the question hardly worth considering. The armature first considered is so incased by massive field magnets, and the fragments would be so light in comparison that but little danger would menace either life or property in case of rupture.—*Scientific American.*

A Firedamp Indicator.—In a letter to a recent issue of *The Times*, Mr. W. F. Howard, of Chesterfield, gives some account of a new firedamp indicator, which is interesting. He says:—"Another invention (Libin's firedamp and escaped gas indicator) has within the past fortnight and for

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the first time in this country been subjected to trial at Chesterfield by myself in concert with Mr. C. E. Jones, of the Chesterfield Gas Works. The result showed that, compared with the Davy safety lamp, still almost universally used in searching for firedamp in mines, the Libin indicator denotes a less per centage either of manufactured gas or of firedamp than the lamp. This was proved first by exact and thoroughly diffused mixtures of ordinary lighting gas with air, 3 per cent. scarcely showing in the lamp, but being indicated with perfect distinctness by the Libin instrument, a 2 per cent. similar mixture being also indicated by the latter only. On further trial in a coal mine at Boythorpe, the lamp showed firedamp in one only of three places, in all of which the Libin instrument indicated its presence. The instrument as used in the mine on this occasion was connected with a small electric battery carried in a waist belt, and connected by wires with a bell; by a sliding contact arrangement no spark was given off. In this form it can be employed for examining any place in a mine that can be examined with a safety lamp. For positions in which it can be permanently fixed, it is designed to communicate and keep up intelligence of the state of the main return airways to the manager's office. In both forms, fixed and portable, but chiefly in the former, there are wide fields for its use elsewhere than in mines, particularly for the detection of gas in coal bunkers on board ship, and in buildings. On board ship, especially at different points among the cargo, where safety lamps cannot be introduced, the automatic registration of several Libin's detectors, each having a separate wire and indicator, and employed either separately or together with similarly equipped thermometers, would denote the place, degree, and extent of danger. Such warnings would, of course, suggest means of remedy in each particular instance, and ultimately, it may be expected, would lead to better methods of stowing and insure safety."

Resistance of the Electric Arc.—Messrs. Ayrton and Perry have recently made some experiments with the object of obtaining further information as to the resistance offered by the electric arc, to supplement the data obtained by the late Mr. Schwendler in his 1878 experiments. The latter gentleman came to the conclusion that the supposition that the resistance of an arc of constant length was inversely proportional to the current which passed through it was highly probable. Messrs. Ayrton and Perry's first series of experiments were made with Grove cells, so arranged that 30, 40, or 50 could be thrown in or out of circuit, so as to increase or decrease the current without any interruption. An ammeter was placed between the cells and one of the carbons, and a voltmeter between the two carbons, so as to measure the current going through the arc, and the difference of potential between the carbons. The position of the arc was adjusted to a fixed distance, and the experimenters managed to take three readings before the light went out. The following are the results:—30 cells gave a current of 6·52 amperes, a difference of potential between the carbons of 30·4 volts, and the work in foot-pounds per second in the arc amounted to 146·2. With 40 cells the current became 10·16, the difference of potential 30·4, and the work 227·8. With 50 cells the current was 11·92, the difference of potential still remaining steady at 30·4 volts, whilst the work increased to 267·2 foot pounds per second. Subsequent experiments were made with a Brush dynamo, readings of the voltmeter only being taken, and the current being alternately trebled and diminished to one third by the alteration of resistances in circuit. From the readings obtained it appeared that for a fixed distance between the carbons the difference of potentials necessary to maintain the arc is nearly but not quite independent of the current, the electromotive force requiring to be slightly increased when the current is very much increased. The next question was to ascertain in what way the differences of potentials between the carbons varied with the length of the arc when the current was kept constant. The mode of procedure adopted was to fix on a particular current for each set of experiments. The carbons were then put successively at different distances apart, and the resistance in the circuit varied until the pre-arranged current was flowing through the arc, when instantly the arc was projected on a screen by a lens of known magnifying power, and the actual projected distance between the carbons on the screen read off, and the difference of potentials between the carbons ascertained. A number of experiments were made in this way with a Brush machine for currents varying between 5·5 and 10·4 amperes, the distances between the carbon points from 0 to one-and-a-quarter inch, and the difference of potential varying from 0 to 140 volts, the carbons being ·24 inch thick. The result showed that at first the difference of potentials necessary to maintain the arc increased rapidly with the distance, and that at a distance of about one-tenth of an inch it was about 60 volts. This increase continued up to one quarter of an inch distance, after which the difference of potentials necessary became nearly proportional to the increase of distance, being about 54 volts per inch increase. The experimenters plotted these results, and obtained a curve for the increase very like that obtained by Mr. C. F. Varley for the discharge through a vacuum tube, and, Drs. W. de la Rue and Hugo Müller for the connection between the electromotive force, and the distance across which it would send a spark. The result of the experiments showed that the difference of potentials between two carbons necessary to produce an arc depends almost entirely on the distance between them, and hardly at all on the strength of the current. A detailed account of these experiments will be found in the *Philosophical Magazine* for May. Messrs. Ayrton and Perry conclude by expressing their opinion that "in all probability the conduction from particle to particle in a microphone is of the nature of a small electric arc, or rather perhaps a convective discharge."

Prospects of Electric Lighting. — An interesting lecture under this title was delivered by Mr. T. P. Barkas to the Tyneside Students' Association, in the rooms of the Newcastle-on-Tyne Literary and Philosophical Society, on Thursday, April 26. The lecturer began by tracing the history of electrical science from the time of Thales, of Miletus, to the present day. "Electricity during the present century," said Mr. Barkas, "has revolutionised our conceptions of the powers and possibilities of nature, and has transformed the earth into a fairy palace, more wonderful than the palace of Aladdin, with all the properties of his wonderful lamp." And yet how far we are from any complete conception of what electricity really is. Notwithstanding the strides that have recently been made in electrical science, we may say with Byron in his "Manfred,"

> Science
> Is but an exchange of ignorance for that
> Which is another kind of ignorance.

Mr. Barkas then proceeded to give some account of the earlier forms of arc and incandescent lamps, such as Staite's, King's, and Starr's (all of which have been illustrated in our pages within the last year or so), and their successors, together with the dynamos that have been invented, and have enabled the electric light to enter

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into competition to a certain extent with gas. It was the want of these dynamos, the lecturer pointed out, which had caused the earlier experimenters in electric lighting to give the matter up as impracticable, although gas at that time had only just been introduced, and was of very bad quality. He then briefly alluded to the great improvements that were successively introduced into the manufacture of gas, and how this means of illumination had advanced in public favour, mentioning, *en passant*, that five years ago Newcastle £100 gas shares sold for £110, whereas a few days ago they were sold in large quantities at £160. He contrasted this with Brush £10 fully paid shares, which not long ago sold for £56, but were now unsaleable at £8. The lecturer then explained the electric units now in use and their values. Passing on to consider arc and incandescent lamps, he explained that all forms of metallic incandescent lamps have given place to carbon lamps, notwithstanding the fact that metal is more easily raised to incandescence, because the former are more easily fused, and also because the resistance of metals increases with heat, whilst that of carbon filaments decreases. To illustrate this he gave some figures relating to various incandescent lamps, showing their resistances when cold and hot. According to Mr. Barkas, Maxim lamps have a resistance of 70 ohms cold, and 35 ohms hot. Swan lamps are 70 ohms cold and 30 ohms hot, Edison lamps are 250 ohms cold and 125 ohms hot, and Lane-Fox lamps 70 ohms cold and 38 ohms hot. The secondary battery the lecturer traced from the experiments of Gautherot, in 1801, to Planté and Faure at the present day. "Theoretically," he said, "secondary batteries appear to be very efficient—that is, they ought to store E.M.F. put into them, but practically, from obstacles of various kinds, they do not. There are many practical difficulties in the details of working secondary batteries, and I have seen long rows of Faure batteries, sufficient, if in proper order, to light a theatre with 1,000 lamps, unable to light a few lamps in a shop, because of some undiscoverable errors in their arrangement, or some unexplained or undiscovered local discharge." Mr. Barkas concluded by giving an account of the electric light mania of three years ago, and the feverish way in which shares in the companies then floated were snapped up, contrasting the high price paid for those shares with the discount at which many now stand. From this comparison he drew his own conclusions, which were that the outlook for electric lighting was a gloomy one. Here we are at variance with Mr. Barkas. The mania of the past few years is coming fast to its legitimate end, many companies then started have already been wound up, more are in process of being wound up, and there are probably more to follow. Thus a much-desired clearance is being effected, which will leave room for those who do know something of electric lighting, and have some right to the title, "electric light engineers." We think that Mr. Barkas will change his opinion as to the future of electric lighting before many more years have passed over his head, though we have no doubt that a great deal of the money so rashly subscribed by the public, to the great benefit of company promoters, will be lost.

Repairing Cables off Sicily.—We make the following extract from the *Gazzetta di Messina* of the 28th March:—"On the 21st inst. the operations undertaken by the English steamer 'Volta,' belonging to the Eastern Telegraph Company, under the command of Captain Pattison, with the object of repairing the cables between Sicily and the main land, were brought to a satisfactory conclusion. A new cable consisting of three wires was laid, and another which had ceased to act was taken up and repaired. The Italian Telegraphic Administration, for whom the aforesaid operations were carried out, was represented by the Inspector-General of Telegraphs, Commendatore Signor Clemente Viale, whilst the Eastern Telegraph Company was represented by its own superintendent, Chevalier Eggington, the electrical tests and experiments being entrusted, as far as they concerned the above-mentioned company, to their electrical engineer, Mr. James Anderson. The Eastern Telegraph Company, whose network of submarine cables stretches over such a vast extent of our globe, reaching to the most distant seas, is possessed of ways and means in proportion to the vastness of its undertakings. The company is the owner of several vessels specially fitted up with the necessary apparatus for carrying out undertakings of this description. The 'Volta,' whose name is a glorious one in Italy, is one of the finest and newest of these vessels. Those who have had the pleasure of visiting this model ship cannot but have admired the way in which everything that science can devise as the most useful and the newest in the way of submarine telegraphic appliances is to be found on board—from huge and powerful steam engines for sinking and taking up submarine cables to the most delicate instruments for testing the electric condition of the same. Besides all this, she has on board every description of nautical instrument, and is fitted up with everything that is conducive to comfort in the way of tasteful and elegant decorations and other arrangements. Another point which renders this vessel specially worthy of notice is that the lighting of the saloon, of the passages, of the cabins reserved for the captain and his officers, is effected by Swan lamps. It is a pleasant light, having a rosy and mellow tint, and distributed through a proportionate number of lamps. It is not a dazzling light, nor such a light as is generally used in illuminating a public square, but a light suitable for a saloon or sitting room. On the bridge there is a 'Rechercher,' or search light of capacity sufficient to light up with the clearness of noon-day the decks of the vessel and her neighbourhood for a radius of one kilometre. This apparatus is most useful in the work to be done, and for the safety of the ship. In conclusion, everything is so well arranged on board the vessel, that whoever visits her cannot fail to come away delighted. The good impression made on any one visiting the vessel is completed by her worthy commander, Captain Pattison, who is the model of a seaman. His build is of the Herculean order, but he has, withal, an expression of kindliness and good nature, coupled with a dignified mien, which makes him a favourite at once. In fact, in his case, outward appearance is a sure index to a true and kindly heart. As a proof of this we may state that on the 21st inst., whilst he was carrying out his operations in connection with the submarine cables, he came upon the fishing smack called 'Due Fratelli,' which had run aground on Pezzo Point, near Cannitello, and was in a desperate plight, the seas making a clean breach over her. Captain Pattison at once and unasked tendered her his help, set her afloat again by means of his engines, and rescued her from her perilous position. Subsequently he fell in with another sailing vessel which had also run aground, was without any boats, and had her bowsprit damaged. To her also he offered his services, and would have rendered them to her had not her captain some short time previously telegraphed for a tug to tow her into the harbour of Reggio. At this time the weather was stormy, and a heavy gale was blowing from the west. Such services rendered at a time when Captain Pattison was performing a most important and delicate task undoubtedly show that he has the generous heart and the intrepidity of a true seaman."

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SOME ELECTROSTATIC AND MAGNETIC RELATIONS.

BY OLIVER HEAVISIDE.

(CONCLUDED FROM PAGE 559.)

9. The division of physical magnitudes by Hamilton into scalars and vectors is not merely one of the most useful ideas ever conceived, but is also one that is perfectly intelligible to every one as a natural division. Scalars being such as pressure, temperature, density, and so forth, directionless, and requiring but one specification, viz., magnitude; and vectors being such as displacement, velocity, force, &c., involving direction as well as magnitude, and, therefore, requiring three specifications (as the magnitudes of the components in three rectangular directions; or the magnitude of the vector itself, and two data to specify its direction), it is impossible to confound scalars with vectors. They are distinct and separate entities. The word entity is obviously applicable to a scalar, whilst it is equally applicable to a vector in spite of its three data. The data may be of different kinds, yet the final result is the same, viz., a definite directed magnitude.

But although we cannot combine a scalar with a vector to form a fresh scalar or fresh vector, or a new quantity having an individuality of its own, it is sometimes convenient to pair them, and the result is called a quaternion, the name implying the four data. But a quaternion is always merely a definite scalar and a definite vector paired, and is consequently a purely artificial idea, not having the same naturalness as a scalar or a vector. A and C are thus quaternions, whilst Z, B, and D are pure vectors. Nevertheless, so far as the potential property goes, there is no occasion to draw any distinction between them, for we have Z = potential B, A = potential C, and B = potential D. [In the quaternion analysis, however, a quaternion assumes more definiteness than in the above, being in fact the ratio of two vectors, *i.e.*, the operation that must be performed upon one vector α to turn it into another β. Imagining them drawn from the same point, we may turn α into β by first rotating α through a definite angle in their common plane until it coincides with β in direction, and then by stretching or shortening it till it is identically the same as β. The angle of rotation and the stretching require each one specification, and the plane of rotation two more, thus making four in all.]

10. In the next place we may notice that the energy properties of Z, A, B, C, and D with the suffix 1 have their parallel in the other set with the suffix 2. We have already discussed the former, relating to the current system, and shown that

$$\Sigma B_1^2 = \Sigma \overline{A_1 C_1} = \Sigma \overline{Z_1 D_1} = \ldots \quad . \; . \; (\alpha),$$

the summations extending over all space. ("Current Energy," III. and IV., p. 390 and 437 *ante*.) Now in the other set we have exactly similar relations amongst the mixed scalars and vectors, viz.:

$$\Sigma B_2^2 = \Sigma A_2 C_2 = \Sigma \overline{Z_2 D_2} = \ldots \quad . \; . \; (\beta).$$

In equation (α) the quantities are all vectors, and the stroke indicates that the product of the numerical values of the two vectors concerned is to be multiplied by the cosine of the angle between their directions. In (β) the stroke appears in the third summation, because Z_2 and D_2 are vectors, but not in the second, because A_2 and C_2 are scalars, and their product is found by ordinary arithmetic.

We may prove the identity $\Sigma B_2^2 = \Sigma A_2 C_2$ in a manner somewhat similar to that employed before in proving $\Sigma B_1^2 = \Sigma \overline{A_1 C_1}$; but the process is now somewhat simpler, owing to the simpler nature of the system of force due to a charge at a point, viz., straight lines radiating equably from the charge, as compared with the closed lines of force of a current.

We have $A_2 = \Sigma \frac{C_2}{4\pi r}$, $B_2 = -\nabla A_2$, and $C_2 = \text{div. } B_2$.

Select any small volume containing the charge C'_2, say, and consider the portion of $\Sigma A_2 C_2$ belonging thereto, viz., $A_2 C'_2$. Here we have

$$\left.\begin{aligned} A_2 &= \text{line-integral of } B_2 \text{ from } \infty \text{ to } C'_2. \\ C'_2 &= \text{surface-integral of } B'_2 \text{ over a surface enclosing } C'_2 \end{aligned}\right\}$$

where B'_2 is the force corresponding to C'_2. The first of these equations follows from the relation $B_2 = -\nabla A_2$, and the second from $C'_2 = \text{div. } B'_2$. Noticing here that any path from infinity terminating at C'_2 will do for the line-integration, and any surface surrounding C'_2 for the other, and that by expanding the surface, starting at C'_2, we may make it sweep over all space, at the same time that its point of intersection by the line chosen for the line-integral goes from C'_2 to ∞, we see that $A_2 A'_2 = \Sigma \overline{B_2 B'_2}$, over all space. Similarly, $A_2 C''_2 = \Sigma \overline{B_2 B''_2}$, if C''_2 be the charge in another small volume. Hence, by including the whole of C_2 we obtain

$$\Sigma A_2 C_2 = \Sigma (\overline{B_2 B'_2} + \overline{B_2 B''_2} + \ldots) = \Sigma \overline{B_2 B_2} = \Sigma B_2^2,$$

since B_2 is the vector sum of B'_2, B''_2, &c. Interpreted for electrostatics, C_2 being density of electricity, A_2 its potential, B_2 the force, the quantity ΣB_2^2 is double the electrostatic energy expressed in terms of the square of the force throughout the whole dielectric with unit capacity, whilst in the equivalent form $\Sigma A_2 C_2$ it is expressed in terms of the charges and their potentials. It, $\left(\frac{1}{2}\Sigma B_2^2\right)$, is the amount of work expended in setting up the state of electrification, and given out again when the charges are allowed to combine and neutralise by conducting paths, in the form of heat ultimately. We must not, however, hastily conclude that $\frac{1}{2}\Sigma B_2^2$, when B_2 stands for the magnetic force of a permanent magnet, really represents the energy of the magnetisation, a matter we shall not here touch upon.

11. The other identity $\Sigma A_2 C_2 = \Sigma \overline{Z_2 D_2}$, where Z_2 is the v.-potential of B_2, and B_2 that of D_2, may be thus established. Let F, G, H be the components of Z_2 and F_1, G_1, H_1 those of D_2. Then, because $A_2 = \text{div. } Z_2$, we have

$$\Sigma A_2 C_2 = \iiint C_2 \left(\frac{dF}{dx} + \frac{dG}{dy} + \frac{dH}{dz}\right) dV,$$

and, by integration "by parts" through all space,

$$= -\iiint \left(F \frac{dC_2}{dx} + G \frac{dC_2}{dy} + H \frac{dC_2}{dz}\right) dV.$$

But $-\frac{dC_2}{dx} = F_1$, &c., since $-\nabla C_2 = D_2$; hence

$$\Sigma A_2 C_2 = \iiint (FF_1 + GG_1 + HH_1)\, dV = \Sigma \overline{Z_2 D_2}$$

in our notation.

12. We saw in Article IV., "Current Energy," that the division of the arbitrary magnetic force B into two fields, B_1 and B_2, the first due to current, the second to magnetism, is effected in such a manner that

$$\Sigma B^2 = \Sigma B_1^2 + \Sigma B_2^2,$$

the products of B_1 and B_2 completely annulling. We now see that the fields thus obtained have precisely the same energy properties, employing the corresponding connected functions in each case, without the necessity of distinguishing between the different natures of the functions.

We shall, of course, find the same relations in the quantities Z and D, since they are similar to B, being pure vectors, of which Z_1 and D_1 are the closed tube portions, and Z_2 and D_2 the open. Thus

$$\Sigma Z^2 = \Sigma Z_1^2 + \Sigma Z_2^2, \text{ and } \Sigma D^2 = \Sigma D_1^2 + \Sigma D_2^2.$$

But we cannot expect to find this property when we take the intermediates A and C, which are not pure vectors. For instance, we must not expect to have $\Sigma C^2 = \Sigma C_1^2 + \Sigma C_2^2$, for this would involve v. $\Sigma C_1 C_2 = 0$. This is a vector summation, for, C_1 being vector and C_2 scalar, $C_1 C_2$ in the summation represents a vector of length $C_1 C_2$ in the direction of C_1.

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13. But although v. ΣC_1C_2 does not in general vanish, yet we have $\Sigma C_2 = 0$ and v. $\Sigma C_1 = 0$ separately. The former we have assumed from the beginning, for it merely expresses that there is just as much positive as negative magnetism, which is always the case in any arbitrarily assumed state of magnetisation. The same is true for electricity, but we must exclude lines of force going out to infinity without returning, or we may terminate such lines upon a surface enclosing the whole space considered. In fact, $\Sigma C_2 = 0$ separately for every tube of force.

The other equation, v. $\Sigma C_1 = 0$, interpreted for current, says that, in any system of closed currents, the current has, on the whole, no preponderance in any direction. As an illustration of the meaning of this, divide the whole space occupied by current into a very large number, say n, of equal small volumes, and draw n vectors from a fixed point, representing the current in each volume. If these were forces acting upon the point, they would exactly balance. This may be seen by first noting that a closed *line* has no preponderating direction, since it returns into itself, and next that we may split up any system of current into closed tubes of infinitely small section, each conveying a definite current, and that, although the section of a tube may vary, yet the density of current then varies exactly inversely; consequently v. $\Sigma C_1 = 0$ for any tube, as for a closed line, and hence v. $\Sigma C_1 = 0$ universally. Similarly v. $\Sigma B_1 = 0$, and the same for all the quantities with the suffix 1, since they have no convergence.

14. But we do not have v. $\Sigma B_2 = 0$, since the lines of B_2 are not closed. Let B_2 be electrostatic force, and consider a tube of force of section dS starting from one conducting surface and terminating upon another. $B_2 dS$ is constant, although B_2 and dS may vary along the tube, and this product is numerically equal to the amount of positive and negative electricities at the terminal sections of the tube upon the conducting surfaces. If we join the ends by a tube whose axis follows the shortest distance between them, and let the same amount of force as went from + to − electricity along the real tube return by the other, we have a closed tube, and v. $\Sigma B_2 = 0$. Consequently v. ΣB_2 for the real tube is numerically equal to the product of the amount of terminal electricities into the shortest distance, l, between them, and is directed from + to − along l.

As a magnetic illustration, let there be a cylindrical magnet of length l, and of any section, with plane faces perpendicular to l, uniformly magnetised parallel to l, and let B_2 be its magnetic force. Then v. ΣB_2 throughout all space is numerically equal to the whole magnetic moment, and is directed from the N to the S end, parallel to l. We may verify this as follows:—Given that the magnetic force in a cylindrical space similar to that of the magnet is of uniform strength B parallel to l, and directed from left to right say, and that outside the space there is no magnetic force at all, what is the distribution of current and of magnetism that would produce such a field of force? We must find the curl of B for the one, and its divergence for the other. Plainly the latter is B per unit area of the terminal faces, positive at the left end, negative at the right. Hence the left terminal face has surface density of magnetism + B, and the right − B. The curl of B is plainly confined to the curved surface of the cylinder, where B is tangential, and suddenly changes from B to zero in passing through the surface from within outward. Turn B at the surface through a right angle, and we obtain the surface curl. The current, therefore, circulates round the curved surface of the cylinder in planes perpendicular to its length, and is of density B per unit of length of the cylinder. The magnetic fields of this current, say B_1, and of the terminal magnetism, say B_2, together produce the uniform field of strength B within and zero outside. But for the former we have v. $\Sigma B_1 = 0$, and since v. ΣB is plainly = B × volume, and therefore = magnetic moment, and directed from left to right, the same must be true for v. ΣB_2, *i.e.*, for the magnetic force of the magnet with which we started. In fact, what we have done is to make a current flow round the magnet of such a strength and direction that the external field of force is exactly annulled, and of course we make the supposition that the magnetisation is rigid, or unaffected by its exposure to the magnetising force of the current. Now, on the understanding that the force of the magnet is derived from the magnetic potential as well within as without the magnet, we see from the above that the internal force of the magnet is annulled at the same time as the external by the superimposition of the magnetic force of the current, leaving only the uniform field B. On the other hand, if we were to employ the "electro-magnetic definition" of the internal force of a magnet, we should find that the current field exactly neutralised that of the magnet, both within and without.

15. Going back to Z, A, B, C, D, we have, in spite of the identity of the potential property of their constituents with suffixes 1 and 2, and of the energy properties as above mentioned, a striking apparent dissimilarity in the mode of derivation of any term from the preceding in the first set, as compared with the second. Thus, in the first set we have $A_1 = \text{curl } Z_1$, $B_1 = \text{curl } A_1$, and so on throughout, whilst in the second set we have the two operations of divergence when a scalar is derived from the preceding vector, and of space variation when a vector is derived from the preceding scalar. Now it is very remarkable that (as was discovered by Professor Tait) these three operations of curl, divergence, and space variation are really only three different forms of the same operation, the effect varying according to the nature of the function under examination.

We have hitherto used the symbol ∇P to express the resultant space variation of P per unit length, but have applied ∇ only to scalar quantities. Let a scalar function be given, as for example the temperature at every part of space, single valued at any point. Nothing is needed to specify it but its magnitude, it having no direction. Owing to this, its variation from point to point is one merely of magnitude. Measure its rates of increase $\frac{dP}{dx}$, $\frac{dP}{dy}$, $\frac{dP}{dz}$ in three rectangular directions, x, y, z, and call them X, Y, Z. In directions x, y, z draw vectors of lengths X, Y, Z, and compound them (as forces, velocities, displacements, &c.). The resultant vector, say R, shows the direction and rate of greatest increase of P, and, with Hamilton's symbol, $R = \nabla P$. The above method of forming R is what we are literally told to do when we use the full expression for ∇, and its effect upon a scalar is to give a vector expressing the most rapid space variation. There being, as before mentioned, merely a variation of magnitude concerned, there is little difficulty in conceiving the nature of the space variation of a scalar.

Now it appears that when ∇ is applied to a vector, it gives its curl and its convergence respectively. This extraordinary effect of ∇ is not easily to be understood, although symbolically it works out very simply, for there is undeniably a certain amount of mystery about the rules for vector multiplication. But we may gain some insight into the matter by examining in what manner a vector may vary, and by analysing simple cases.

16. In the first place we see that, given a definite vector, as electrostatic force, for every point of space, it may vary as we pass from one point to another as well in its direction as in its magnitude, and it is evidently not an easy matter to form an idea of what its resultant space variation may be if we endeavour to follow the rule for a scalar in the last section. In fact the construction fails, and obscurity prevails. But let us completely separate change of magnitude from change of direction, by starting with a vector which is everywhere directed the same way, and which can, therefore, suffer only change of magnitude. Let its direction be parallel to x, and its magnitude at any point be X. Regarding this as a scalar, it is clear that there is a certain direction in which X increases most rapidly, and that we can find it, and the rate of increase, by the construction for a scalar, viz., the resultant of vectors of lengths $\frac{dX}{dx}$, $\frac{dX}{dy}$, $\frac{dX}{dz}$ drawn in the directions of x, y, and z.

But this will give us neither the convergence of X nor its curl. To obtain them we must separate the space variation of X into two portions, first variation it its *own* direction, and next perpendicular thereto. We may easily recognise a manifest distinction between these two.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XXII.

Our space having been unexpectedly, though unavoidably, contracted, we are obliged for the present to omit giving, as originally intended, a complete illustration of the most convenient modes of working out the tests which have been explained. We have only space for two numbers, which will close the practical instructions for the guidance of those interested in the subject. Having gone through all the ordinary practice in the testing room preceding the shipment of a cable, we shall complete this series with some remarks on the duties that necessarily follow when the manufacture ceases.

Cable factories in London are always on the river side, for convenience of shipping, the cable ship being moored as near to the works as circumstances will allow. The cable is usually run out near the roof, passing overhead, and in some cases crossing the portion of river between ship and shore on guiding wheels raised on a platform fixed on barges. We are chiefly concerned with the details of the electrician's duty, and during shipment this is all, or nearly all, confined to the testing room. A day or two before the shipping commences a set of leads for communication with the ship is laid down in the river bed, the ends being carried respectively to the testing rooms on board and ashore; there are five or six of these leads lashed together, each being

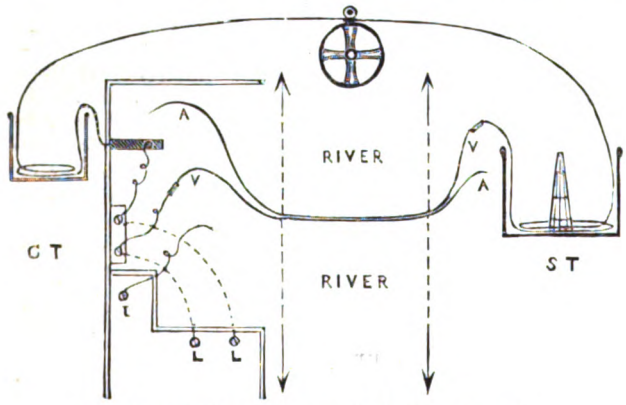

FIG. 46.—Testing arrangements during shipment.

sheathed for protection. Three of them will be generally quite sufficient for testing purposes, the rest for signalling from the ship's tanks to the cable tanks, &c. The former are numbered 1, 2, 3, and are called ship leads. As soon as they are properly laid and the ends conveniently disposed on board, they must be tested for copper resistance, capacity, and insulation, and the values recorded, to be accounted for in the ensuing cable tests, the C.R. to be deducted, and the number of divisions on testing for insulation also deducted from the deflections where necessary. When shipment is about to commence it is usual to alter the connections of the ends at the large commutator, as explained in an early number. This end is sometimes the point first sent over to the ship, as, for instance, when a length of cable is tapered being larger for the first part of its length and purposely tapered till the minimum or deep sea dimension is reached. If this has to be laid with the largest part first submerged (as probably being spliced on to a shore end, always the thickest portion of all cables), the small end would be shipped first, as this going to the bottom of the ship tank the heavier end would be at the top, but if not, then the heavier end would be sent over first. During shipment each section is kept under continuous observation on the electrometer, as previously explained during manufacture. As there are generally three tanks in a cable ship, there may be, though it does not always so happen, three sections running over at one time; in addition to the electrometer observations the sections are tested at intervals varying from two to six hours, or, in some cases, once only every twelve hours. In Fig. 46 we have endeavoured to represent the arrangement now under notice, but confine our illustration to the shipment of one section only, the same instructions applying, however, to three at once. It is difficult to give a clear view of the details which concern the electrician on duty within the limits at our disposal, they are therefore somewhat crammed together, and we have placed only two separate ship leads, but sufficient for our purpose. The cable in the cable tank C T has one end connected to the commutator bar, the other passes over head, being supported on its course by guiding wheels whose rims are grooved, and each of which has a small jockey wheel, which, being also grooved, forms with the other a guiding hollow way by which the cable is eased as it runs along and is kept in its place; one of these is shown in the figure. The cable is supposed to be coiling into the ship tank S T, the end having been left out, as presently to be noted; the two ship leads are marked A and V merely for distinction. The point I represents the terminal for connecting up to the insulation and capacity tests, and L and L′ are the bridge terminals as formerly shown on the bridge plan; the connections are arranged as for a copper resistance test.

When the ship tank is ready and all preparations made, a stout rope is spliced to the cable end which is to go over first, and this rope is then stretched across over the wheels which support it as it runs along to the ship, and a donkey engine on board pulls it over, and thus hauls the end of the cable after it. Several fathoms are hauled over and conveniently disposed before putting any into the tank; the end is brought into the ship's testing room, and is ready for joining up when required, then the coiling in the tank is started. Turning now to the testing. As one end of the cable is on board and it is desirable to take the C.R. test with a metallic circuit, one of the ship leads is joined to this end and the two leads connecting with the bridge terminals are joined, one to the other end of this ship lead by a binding screw, and the other to the cable bar by a plug, the circuit being thus completed.

For taking the insulation test we might if we chose have the cable end on board free in air, and test direct by connecting the lead from I to the bar; but this course is not a safe one, as a rule, for the confusion on board at shipping time is very great, and the end would probably be touched by some one. It is best, therefore, to leave the ship lead connected as just explained and insulate the end which is in the testing room, hanging the end over a peg or placing it safely out of the way; the lead from I will then be joined to the bar, or this lead may be connected by a binding screw to the ship lead, and the bar (with cable end) left insulated. This way of testing saves trouble also in another direction. It is necessary to send a battery man over to the ship to connect up the cables, and if one section only is to be tested the capacity and insulation tests will follow the C.R. test at once, and no communication with the shore is necessary, after the announcement that the ship lead is connected, until the end of the operation.

The tests are all straightforward and the same as usual; one or two points, however, may be noted. It is customary to arrange the plan of shipment beforehand, the details to be chiefly considered being the weights of the various sections of cable, the trim of the ship, the question which lengths shall be first laid, the general order of laying, &c. Many sections are spliced together in one long piece, sometimes amounting to as much as 500 knots. Consequently, as the pieces are successively joined on, the resistance increases, until the time comes when the C.R. amounts to more than can be measured on the bridge with the ratio of 100 to 1, then more than with 10 to 1, and afterwards equal arms must be used, that is, 100 to 100, or 1,000 to 1,000. The lengths are never so great as to necessitate the reversal of the ratio, though the thing is possible at sea, and in the case of a submerged cable when earth currents are strong. The splices are generally made when a length is nearly all coiled out of its shore tank, and the joints, of course, have to be tested. Some disturbance at times accompanies the coiling out and the running over of the cable; the tests are apt to be affected, and when three sections are being shipped at once the effect is stronger. Allowance must then be made

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for this fact in the movement of the spot during insulation tests. For this reason some electricians only test running sections (as they are called) during breakfast and dinner hour, the cables generally, though not always, ceasing running at these times. We have mentioned that the running or shipping sections are kept continually under observation on the electrometer, and as each length when tested must be first disconnected from that instrument, the operator must be very careful to join it up again when he has finished. The insulation test being the last in turn, and requiring 200 cells at least, it is well to apply a short charge immediately at the close of the operation of an opposite kind to that with which it may have been taken, the object being to neutralise the remaining charge before restoring the connection with the electrometer. When three cables are running over at once each will be joined on board to a different ship lead. The connections should be always recorded in a book laid open for the guidance of those successively coming on duty; the resistances of the ship leads also and the lengths of each surviving section at the time must be entered, and every change noted, a fresh entry being made every time to avoid confusion. The cables are identified by the numbers of the shore tanks from which they are being coiled out. The entry is made somewhat in this form:—Tank 4, length = 70 knots, on 4 core and 2 ship lead, C.R. of ship lead = ·2. Tanks 3 and 7, length 98 knots, on 7 cable and 3 ship lead, and so on. The core and cable leads refer to the connections on the commutator, as explained in the early number. As before stated, the intervals between testing these running sections are various, but the electrician on duty should be informed of the progress of shipment in every case, and when a section is to be shipped in a certain length he must be sure to take a test shortly before the end goes over. The rate of running is from two to three knots an hour, so that where a length, for example, of 50 knots is to be shipped he should know when about 48 knots have gone, and at this time take his test; at any rate, it is advisable to get it finished as near as he can to the time when the cable must be disconnected from the testing room. The tankmaster will give him notice when the end should go over, but it is safer also to keep his own eyes open. The absolutely final tests are all taken after every section is on board and the cables are all under water in the tanks. A C.R. capacity, and insulation resistance test with both currents are taken, the cables being put to earth for two hours between each current. When the total length on board is great there may be, perhaps, eight or ten separate lengths; the best way to test these is to arrange with the battery man who connects up on board to join up all the lengths successively and in a known order for C.R., then for capacity and insulation resistance, communication being made with him by an electric bell that he may know when to connect and disconnect. When the last insulation test with one current is finished the man on board will commence joining up in same order over again for testing with the other current. The cables will each have been put to earth as they were tested, and each will have been to earth long enough when its turn comes for this other current, as the insulation test is one for 10 or 15 minutes.

There is a duty that sometimes falls to the assistant electrician at this time, though in some cases it is postponed till the ship is at sea and time is available for writing when nothing else can be done. This duty consists in making up a complete statement of the construction of the whole cable that will finally be submerged in one length. As previously explained the length is made up of coils of core successively joined on and afterwards sheathed. Each coil is numbered, the numbers running consecutively, but they are not all joined on in the regular order of their numbers. As they are added on their numbers are entered in a special book, and since there are several tanks for the different sections the total of the whole length is spread over the various pages of the book. It is necessary, therefore, at the time of submergence to have a list of the order of joining on from beginning to end of the whole cable. Between every two coils is a joint, these also being regularly numbered, and the list is made up by entering the whole of the coils and joints in the exact order in which they were worked into the cable. The test is ruled in columns, and contains the numbers of the coils, line after line, in black ink, and between each two the number of the joint which connected them together is in red ink. Other particulars are also entered in list, but this is the essence of it. It is very valuable as a record, since it is possible by its means to tell in what particular coil a fault afterwards appearing is located—that is to say, reference can be made to the details of the manufacture by this identification, as the time when the core was made, that also of the joint, and any other facts bearing on the question. The history of a joint as to the time when it was made is sometimes suggestive. Joints have been found to have failed, and, when traced, the cause has been seen to be the weather at the time of making. When made in exceptionally cold weather they are known to have been perfectly good at the time, but proved to have turned out weak from the great change in temperature at a later date.

LITERATURE.

The Electric Light—Electric Light Installations. By Dr. A. v. Urbanitzky. [Hartleben, Vienna and Leipzig.]

These two small works form Volumes III. and XI. of a useful series of publications upon electrical subjects edited by Hartleben, of Vienna and Leipzig, which, it seems, is intended to comprise all that has yet appeared, in the way of description and data for practical application, in the pages of all nations. As in most German works of this kind, there has been an immense amount of labour bestowed on collation and arrangement, and the reader may, without difficulty, turn to any of the various divisions of the subjects; as, for instance, the power necessary for the work to be executed and the cost. There are details of many existing installations, some no further away than the Savoy Theatre and the London Docks. We strongly recommend to the notice of local authorities and others who have to deal with "high pressure" or "alternating" promoters the pages devoted to the dangers attending the employment of electricity. The death on board the "Livadia" from an alternating current and others are described. At Pittsburg, Pa., a workman touched a railing put up round a machine, which by some means was in connection with the leads. He was observed to grin and gesticulate, fell backwards, and died immediately. A dark yellow stain running round the throat, and a long furrow extending from the thigh to the ankle of the right leg, showed the path of the current. Otherwise his appearance was that of a man who had fallen into a deep sleep.

There is little attempt made in these books to do more than describe accurately the subjects dealt with, and it seems a pity that the relations of the practical units to the C.-G.-S. units, which do not concern those to whom mainly the books are useful, should be given at all, and worse still that there should be an error in the statement of them. Thus the farad or unit of capacity in the electro-magnetic series is given as 10^9 times the C.-G.-S. unit, instead of 10^{-9} times that unit, which is its proper value. Again, we read "1 h.-p. $= \frac{\text{amp} \times \text{volt}}{746}$," which means literally nothing at all that is true. What the author means to say is that the reading of a certain power in horse-power units is $\frac{1}{746}$ of the reading of the same power in volt-amperes, or 1 h.-p. = 746 volt-amperes. There is a similar want of exactitude in describing a *cheval de vapeur*.

The first volume is entirely devoted to lamps in general, but the two volumes, which are both from the pen of D. A. v. Urbanitzky, must be taken together as one work. They are very thoroughly illustrated.

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CORRESPONDENCE.

THE GRAMME RING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Commenting on Ball's so-called unipolar machine in your impression of April 14, Dr. Paget Higgs makes some interesting remarks upon the action of the Gramme ring. He describes some experiments with the object of disproving "the false notion that the inside wires were of *nil* effect in producing electromotive force," and contends that "the inner wire is as efficacious as the outer wire." Whilst reading with respect anything Dr. Higgs says about dynamo machines, I cannot see that it is proved that the inner wire of the Gramme ring has the efficacy he claims for it. He remarks that the true function of the ring is that of "a particular form of electro-magnet." That it is this, and something more, has, I think, been generally admitted, but what is the particular form ascribed to it? The experiments related show the necessity for an unbroken ring, but do they afford a proof of the equal efficacy of the inner wire? I venture to think not. No practical E.M.F. is developed, Dr. Higgs says, when the iron is in detached pieces, in the ring, "although the 'magnetic screen' is still there." Would it not be more correct to suppose that under these circumstances the magnetic screen is not there? It was shown by Antoine Breguet, as clearly explained by Professor Silvanus Thompson, in "Electric Illumination," that with a continuous iron ring the lines of force are to a great extent screened from the inside wires, and this fact is quite capable of ocular proof. It is so screened because the lines of force entering the ring from one pole pass invisibly through the iron, and out again near the other pole. But with a ring consisting of magnetically isolated pieces of iron the lines of force which enter are very much smaller in number, and they must pass out again somewhere, as iron conducts but does not obliterate or subdue them. In so passing out some will be cut by the inner wires in a sense which tends to neutralise the E.M.F. developed in the outer wires. Thus, if a small piece of iron be placed near one pole of a magnet, it can be seen by means of a card and iron filings that lines of force enter it from the magnet and leave it from the side remote from the magnet. But if one end of a bar or rod of iron be put in its place, and especially if the other end be brought near the other pole, the lines of force will be seen to enter the iron, but not to leave it, till they pass out at or near the distant end. So in the Gramme ring.

Dr. Higgs argues that the incompletion of the ring does not affect the "magnetic screen," and by inference that Breguet's screen theory is wrong. I have tried to show that an incomplete ring means an incomplete screen, and that its completion is as necessary to the ordinarily accepted theory as to that which Dr. Higgs advances, but of which he does not give any particulars, beyond stating that it involves an "electro-magnet system."

I think it may also be argued from the following experiments that the inner wire of the Gramme ring cannot be as useful as the outer wire. If (*a*) a pole of a bar magnet be plunged into a circular coil of wire, an E.M.F. will be equally developed round the coil, because the lines of force are cut equally on all sides. If (*b*) simultaneously with passing the pole into the coil an opposite magnetic pole be passed in the same direction along one side of the coil, then I suppose the E.M.F. developed in the portion of the coil between the two poles will be greater than in the portion remote from the outer pole, because in the latter region the magnetic field is weakest—the increase in the lines of force is least. Again (*c*), if experiment *b* be repeated, but with a soft iron bar substituted for the bar magnet plunged into the coil, an E.M.F. will be devoloped due to the lines of force between the outer and inner poles, but as the inner pole is created by the induction of the outer one, the lines pass principally directly between the two, as may be seen by scattering iron filings over a card, and in this region, therefore, the E.M.F. will be principally developed. It seems to me that this last experiment must illustrate to a large extent the action of the Gramme ring. The filings show that very few lines of force enter the iron at the side away from the pole; in fact, they give Breguet's illustration exactly. (*d*) Repeat experiment *c*, but with two similar poles, one at each side of the iron bar, and the lines of force are seen to pass into the iron at both sides, and to thereby illustrate the superiority of the flat Brush ring with its double poles over that of Gramme.—Yours, &c.,

W. M. MORDEY.

CARBONS IN ARC LAMPS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: May I ask for information through your columns on the following questions?

Supposing the carbons of an arc lamp to be surrounded by water, light would be impossible, but what would be its equivalent?

Might it not be that with the decomposition of the water, and the combination of the oxygen with the carbon, the result would be an increase of the passing current, or, possibly, a reverse one?

Or, in another form:—Suppose a vessel to contain coal dust and water, and the water to be decomposed by an electric current, what would be the result?

As to obtain heat we first have to light a fire, so by starting the combustion of carbon by electricity may it not be that electricity would follow on?

If a battery on this principle were to be successfully constructed, dynamos would be unnecessary, and powerful generators of little weight and capacity would render the application of electricity to vehicles and locomotives possible and easy.

Surely this is worth experiment.

In the hope that some of your readers may think it so, I ask you to insert this letter in your journal.—Yours, &c.,

H. B. R.

26, Upper Hamilton-terrace, N.W., April 30, 1883.

BOOKS ON ELECTRICAL SUBJECTS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Will you kindly allow me to say a few words anent good and bad books on electrical subjects? I am one of the public engaged in the erection of electric lighting apparatus, and I venture to offer a note or two of my experience of the usefulness of books to a practical man. I have read the works of Professors Tyndall, Maxwell, Jenkin, Rankine, and the lectures of many others on electrical and cognate subjects, with one aim in view, namely, the acquisition of knowledge pertaining to my trade. With the exception of Rankine on engineering I cannot say that I have been benefited in the least by careful study of those works. They do not tell me what to do. They do not give any idea of the machines, lamps, or conveying systems used by electrical engineers, and appear to me to be, in a word, only useful to students of theoretical electricity. In your notice of Urquhart's "Electric Light" you appear to have recommended the theoretical books, and to condemn such works as give descriptions of the things actually used and the way to handle them. I think such books as "Electric Light" are by far the most generally useful, especially to practical men like myself, and I have derived more useful information from it than from all the other electrical works I possess.—Yours, &c.,

AN ELECTRICAL ENGINEER.

RESISTANCE OF CARBON.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can any of your readers refer me to any papers on the following subjects:—1. The numerical values of the variation of the resistance of carbon and silicon at different temperatures. 2. The resistance of boron. 3. Does the

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change of form said to occur in carbon incandeseence filaments after prolonged use take place in any other conductor?—Yours, &c., TYRO.

May 2, 1883.

STRENGTH OF STEEL MAGNETS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Can you or any of your readers oblige me with Häcker's formulæ regarding weight and strength of field magnets?—Yours, &c., ENQUIRER.

COMMISSIONERS OF SEWERS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: My attention has been called to a paragraph in *The Electrician* of last week, in which my name is mentioned in connection with the proposed lighting of the City by electricity. In justice, not to myself, but to the Commissioners of Sewers, I have to ask the favour of your allowing me to say a few words in answer.

The commission requested me to report on the various tenders presented to them entirely on account of what they had acquired and learnt concerning me. I had not a single friend amongst them, the gentleman who proposed me was a stranger until a few weeks before the election came off. Who my seconder was I even now do not know. With the exception of one other gentleman with whom I have been officially brought into contact over the matter, I have not the privilege of being acquainted even by sight with any member of the commission.

I was not the only one the commission appointed to report on the subject, neither does my name stand first.

With regard to myself I cannot in good taste speak; that I can leave to those who have long professionally known me, should they deem there is any necessity on their part to do so. But, perhaps I may remark that you, sir, have not unfrequently for some time past done me the honour of mentioning my name in your paper, and that in a very different manner indeed from the way you wrote in your last issue.

If the report which I have presented to the Commissioners of Sewers had been made public, it would, of course, have been right and proper for you to criticise it in as stringent a manner as you pleased. But when two independent reports are before the commission, one from him whom you mention as declining to act as *collaborateur* with me, and the other from myself, and the commission are about to decide which shall be adopted, his or mine, I cannot but think that you will, on reflection, agree with me, that in common fairness such a paragraph, prejudging mine, should not have been inserted in your paper.

Whether such a personal attack as your article, read as a whole, appears to be is not one calculated to prejudice the minds of the commissioners, and cause them to lean in favour of adopting the report of him whom you describe as "standing in the front rank of those connected with electrical matters," I must leave you to judge.

I should, however, have thought that any report emanating from this great authority on electric lighting could well have been left to take care of itself—if opposed to mine—without any aid from your journal.

May I ask whether "rumour," sir, who appears to have acquainted you with so much, has mentioned the name of my so-called *collaborateur*, and also whether we were opposed on another matter some time ago, which necessitated my adopting a very decided course of action?—Yours, &c.,

MUSGRAVE HEAPHY.

19, Lombard-street, E.C., 30th April, 1883.

[We were altogether unaware that any report had been sent in by Mr. Heaphy or any other authority till we received the above letter. Rumour has not given us the information hinted at by our correspondent in his last paragraph. We have no reason to withdraw our previous remarks, thinking that the ablest available talent should be at the service of the Commissioners of Sewers, and surely we may be allowed to suggest that this talent lies among men who have devoted their lives to electrical and cognate subjects, and have made their mark in the history of science. Mr. Heaphy must be congratulated that so high an opinion is held of his abilities after comparatively a short career in electrical work. Mr. Heaphy informs us that it is more than six years since he first commenced investigations into electric light matters.—ED. *E.*]

HIGH SPEED DYNAMOS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: Are not high-speed dynamos a mistake? I notice that the large dynamo machines of Edison and Gordon are coupled direct to the engine which drives them, whereas in very high-speed dynamos, as in that of Ferranti, the efficiency of which we have heard so much, the shafting and belting are very considerable items in the erection of the installation. I think the Ferranti installation at the Westminster Aquarium is a fine exhibition of shafts, belts, and pulleys, and although the machine may be the most interesting, it strikes me that high efficiency cannot be obtained when hundredweights—perhaps tons—of machinery have to be actuated at high speed before the necessary power is communicated to the dynamo. Besides the friction of this, the air churning has to be taken into account, and 6,000ft. per minute in belting, some 20in. wide altogether, is not particularly suggestive of a dead calm. Lastly, the engineer notices the great strength of the building, which is most requisite when power in such quantity has to be geared.

I should very much like to hear other opinions about this, but it seems to me that when the necessary foundations, pulleys, shafts, and, worst of all, belts are placed in position to propel such a machine as the one mentioned, most of its cheapness and efficiency and all claim to compactness is gone.—Yours, &c., W. S. H.

TESTS OF INCANDESCENT LAMPS.

[We have been favoured by Mr. H. Joel with the following table of tests. It must be noticed, however, that such tests are of limited value, inasmuch as the various lamps are not maintained at the normal candle-power for which they are constructed. Our own experiments show that the Maxim lamp, for example, is far more economical and efficient at 50 or 60 candle-power than at 20 candle-power.—ED. *E.*]

COMPARATIVE TESTS OF DIFFERENT INCANDESCENT LAMPS AT 20 CANDLE-POWER.

Name.	Resistance cold ohms	Current in amperes	E.M.F. in volts.	Watts.	Remarks.
Maxim	66	1·56	56	87·36	Average of 7 lamps.
Maxim	110	1·1	65	71·5	Average of 5 lamps.
Swan	150	1·38	93	128·34	Average of 2 lamps.
Swan	67	1·5	51	76·5	One lamp.
Swan	63	1·46	47	68·15	One lamp.
Woodhouse and Rawson	69	1·53	57·5	90 85	Average of 10 lamps.
Duplex	130	1·32	94·4	124·708	Average of 10 lamps each tested in series
Edison	245	0·82	112	91·84	Average of 10 lamps.
Gatehouse.....	120	1·0	64	64·0	Average of 10 lamps.
Gatehouse.....	100	1·25	54	67·5	Average of 10 lamps.
Gatehouse.....	150	0·9	72	64·8	Average of 10 lamps.

All the above tests were made with the same instruments, and under the same conditions, 20 candle-power being observed throughout.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended 27th April amounted to £2,990.

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THE ELECTRICIAN.

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ANSWERS TO CORRESPONDENTS.

A. A. CAMPBELL SWINTON.—*Messrs. Siemens Brothers and Co.'s address is* 12, *Queen Anne's-gate, Westminster, S.W., and that of the Anglo-American Brush Corporation, Belvedere-road, Lambeth, S.E.*

R. M. G. B.—*The address of the company referred to in your letter of the 26th ult., is Tower Chambers, Moorgate-street, E.C.*

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AMALGAMATION FOR THE SUPPLY OF ELECTRICITY.

We have not yet heard the result of the meeting convened in New York, on the 20th ult., for the purpose of considering the desirability of combination among the electrical companies of that and other cities; but whatever may have been decided on that occasion, sooner or later the propositions then set down for discussion will have to be definitely adopted, not only in the United States, but in most of the countries of Europe. The necessity for united action on the part of the various undertakers engaged in supplying electricity is every day becoming more obvious; and although the urgency for it is perhaps not so pressing in this country as in some other places, prudential considerations should induce us to shape our plans in good time on the basis recommended by the "Committee on Underground (Electrical) Communication" in New York, rather than proceed in a reckless course of competition, only to retrace our steps when the mischief is done.

There are no exact statistics available in reference to the purveyors of electricity in this metropolis. In some respects we are better off, in others probably worse, than our friends across the Atlantic; but, on the whole, the arguments applicable to them will apply to us. According to a circular convening the meeting above referred to, there are in New York twenty-one corporate bodies engaged in transmitting electric currents for the use of the public. Of these, eleven are telegraph companies, including fire alarm and police telegraphs; one is a telephone company; five are electric lighting and power companies, and four others are for miscellaneous purposes—all these companies carrying their wires overhead, or "exposed to view" as the circular puts it, along the routes of a greater part of their entire systems.

It is not quite clear whether this includes every one of the New York electrical companies who possess wires, or only those who erect them above ground. The point is immaterial, however, for the indefinite multiplication of overhead wires is as objectionable on grounds of public safety as the indiscriminate cutting up of the streets would be on grounds of economy. It seems to be assumed, and we think quite correctly, that overhead wires must come under; and that in any case the additional wires required for electric lighting will have to be placed below ground. The question then arises, Is each independent company to apply for powers to take up the roadways and to construct separate subways for every separate system, or are they all to combine, either in a common purse, or in the construction, so far as may be practicable, of a common subway? Several of the existing companies possess what are called "underground rights," that is to say the powers legally required to break up the streets, and some of them have already made use of these powers—notably the Edison Company, which has now in successful operation about sixteen miles of underground wire for supplying electric light.

Now, it is obvious, as the circular pointedly remarks, that the other twenty companies cannot follow the Edison Company's example. Even if they were persuaded or compelled to do so, the expenditure of capital and the disturbance of the streets would become an intolerable burthen. How, then, are the various interests to be so far combined as to form a working scheme, so that the wires of all the companies may find a safe and comparatively inexpensive lodgement underground? The subway scheme is, of course, very simple, and the ideal at which the promoters aim is that wherever an alarum, a telephone, a time wire, a stock register, lifting or pumping power, or an electric light, is required, an attachment to the main supply systems should be practicable at once and without molesting the street.

A system so comprehensive and perfect as this may be considered perhaps a little too ideal, but so far as its mechanical difficulties are concerned it is a quite practicable one. The real difficulty is electrical. To make such an enterprise profitable it must have for its customers the telegraph signalling companies of all classes as well as the electric lighting companies. To carry these two sets of wires side by side has hitherto been an electrical difficulty, but it is one which the committee confidently believes they are able to solve by means of patents already taken out relating to insulation, induction, and various other matters that have to be dealt with in a problem of this kind.

The committee, in fact, have issued two circulars, one

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inviting attendance at a meeting of all the companies interested; the other giving a list of patents acquired by the Gramme Electrical Company—the prime mover in the matter under consideration. The first circular is the cannon; the second the shot with which it is charged, a four hundred pounder it may be called, for the number of patents claimed by this company and its auxiliaries actually reach that figure; and the object of the discharge is intended, we presume, to strike terror into any smaller detachment presuming to fire an independent scheme of its own. Its effect, of course, will depend more upon the quality of the shot than upon its weight. But the moral is the same for us who are at present mere lookers on—namely, that the conviction has already come home to a large and influential combination of electrical companies that their future prospects will greatly depend upon judicious co-operation with telegraph and telephone companies for the establishment of a system of electrical underground communication common to them all.

THE COST OF ELECTRICITY.

We give in another column a carefully drawn up estimate for a large electric light installation, together with the appendix attached to the estimate, giving the approximate cost of electricity as compared with gas. We have probably had greater advantages than most people in the study of this estimate, having been some time since favoured with a copy, and having discussed it more than once with those interested in the work. It is almost needless to say that the result is a surprise even to us, somewhat sanguine as we are of the merits of electricity when compared with gas, but although we have again and again gone carefully through the figures we have been unable to modify them to any considerable extent, not sufficiently, indeed, to interfere with the result, that under the circumstances specified electricity is far cheaper than gas. The Telegraph Construction and Maintenance Company is a company known, not only for its able mangement, but for its great, its extraordinary care to be always on the right side. In its work every possible contingency seems to be thought of and provided for, hence its long record of successes, and we cannot but feel that in entering upon a new branch of the applications of electricity as great or greater care will be expended in obtaining complete data and being over careful rather than otherwise in the estimating. There are many points which might be noted in this specification, but we must be content for the present to note but few of them. The Nottingham Corporation would be quite safe to accept the tender; there can be no doubt on that point. The risk, if any, lies with those who tender. Although the number of lamps mentioned is 60,000, this means that at least 120,000 lamps might be wired, for it is hardly conceivable that at any time more than one half the lamps in a town would be used at one and the same time. It has been suggested that attention might be called to the paragraph relating to "mains," and comparisons made as to the section proposed to be supplied and the sections required by the formula of Sir W. Thomson given at the York Meeting of the British Association (*vide Electrician*, Vol. VII., p. 295). It will be seen that the company propose to work for thirty days, to allow of a fair test of the apparatus, and a large proportion of the sum payable is held by the corporation till after this complete test. We shall be glad to receive the opinions of readers upon this subject, and hope so definite a scheme may lead to a great success.

THE PRACTICAL MEASUREMENT OF ELECTRIC CURRENTS AND ELECTROMOTIVE FORCE.*

BY PROFESSOR JAMES BLYTH, M.A., F.R.S.E.

Till very recently the measurement of the two electrical quantities—current intensity and electromotive force, was only, or, at least, mainly, needed for purposes of physical research, and hence the instruments employed were of the delicate and unportable kind usually found in physical laboratories. Provided perfect accuracy were secured, no special care was taken to make the instruments unwieldy or easily moved from place to place without detriment. Within the last few years, however, matters in this respect have considerably changed. During that time electricity, or, rather, electrical energy, has become a really marketable commodity, and already several companies have been formed for its supply, while the users of it both for electric lighting and electrical transmission of power are daily on the increase. This has created a demand both on the part of suppliers and users for handy, and at the same time, accurate instruments, whereby the amount of this energy can be determined.

In order to measure the energy in any part of a given electrical circuit two quantities require to be known. These are the electromotive force acting in that part of the circuit and the quantity of electricity passing through it. The former is expressed in volts and the latter in colombs, the volt and the colomb being the adopted practical units of electromotive force and quantity of electricity respectively.

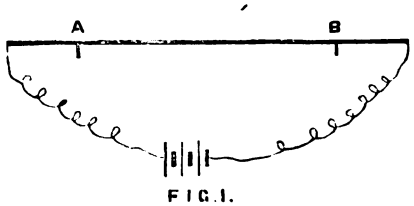

FIG. 1.

Let A and B be two points in any electrical circuit which a current C is passing, and let E be the difference of potential, that is the electromotive force, between A and B; then W, the electrical work spent in driving a quantity, Q, of electricity from A to B in the time t is

$$W = \frac{t}{EQ} = E\,C\,t.$$

Hence rate of doing work $= \frac{W}{t} = E\,C$. By dividing by 746 this is reduced to horse-power. Hence

$$H.\text{-}P. = \frac{E\,C}{746}.$$

From this we see at once that, unless we employ some form of meter which measures energy directly, we must have two instruments before we can measure the electrical energy in the part A B of our circuit, the one a galvanometer or current meter for measuring C, and the other a voltameter for measuring E.

For laboratory work merely, any of the well known forms of galvanometer, such as the tangent galvanometer, the sine galvanometer, or various forms of electro-dynamometer, are very accurate and suitable. As already said, however, they are all too delicate and bulky to satisfy the requirements of present electrical engineers. Hence various inventors have endeavoured to produce modifications of the instruments which shall have the properties of small size, accuracy, and portability. Excellent examples of such are the ammeter of Professors Ayrton and Perry and the graded galvanometer recently invented by Sir William Thomson. In all instruments of this class

* Abstract of paper read before the Society of Arts, Glasgow.

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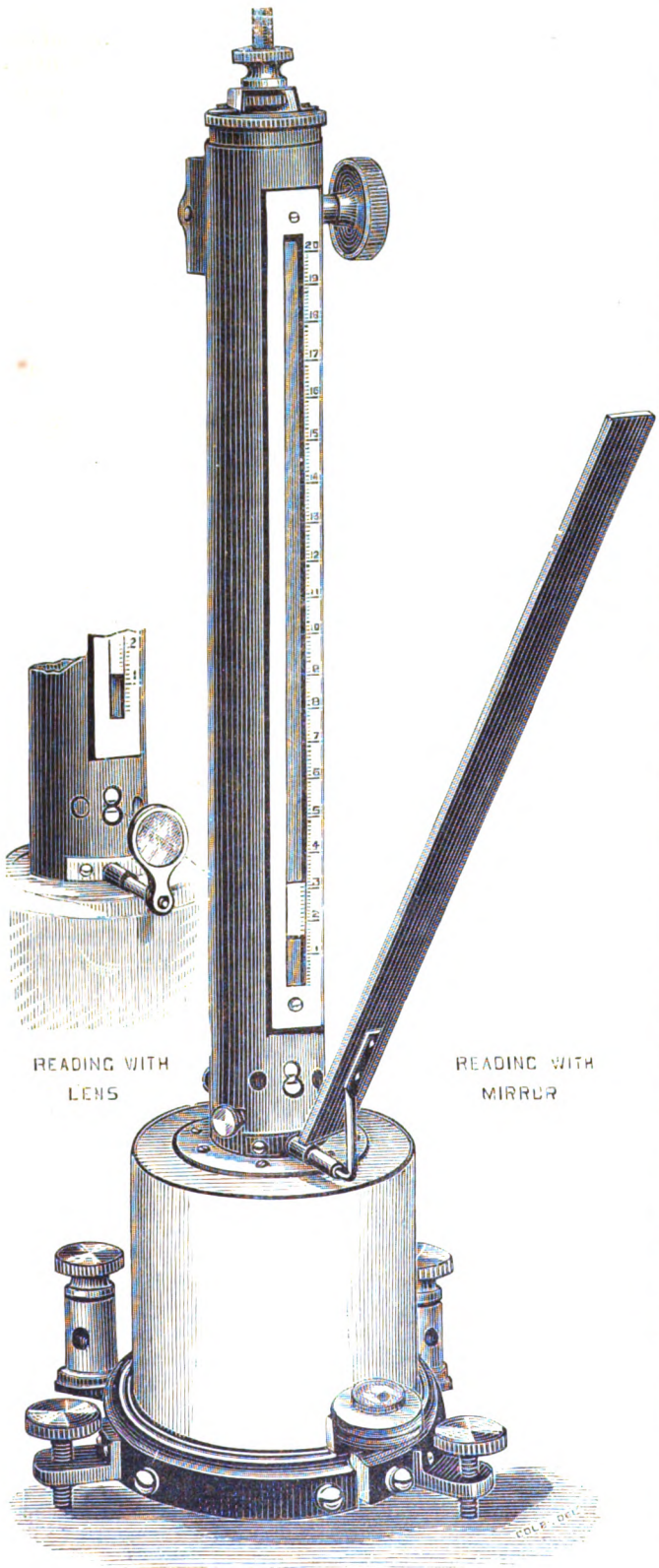
the current strength is deduced from the deflection produced by it on a magnetic system suspended so as to be free to move in a magnetic field of a nearly as possible constant intensity. This field may be either that due to the earth's magnetism or be produced artificially by suitably-placed



permanent magnets. To get the current strength, some function of the angle of deflection (usually the tangent) is multiplied by a certain constant peculiar to the instrument. This constant involves as a factor some component of the intensity of the magnetic field, and hence will vary if that intensity varies. Now, as is well known, this intensity varies both on account of variations in the earth's magnetism, and still more from the presence of large masses of iron or dynamos at work in the neighbourhood of the instrument. Hence, unless special precautions are taken, the readings of of all such instruments are apt to be in error. Besides this the magnetism of the permanent magnets which produce the magnetic field is subject to gradual variation in the course of time, arising from the fact that no substance possesses perfect magnetic rigidity; and hence, on this account, the instruments referred to require to be periodically readjusted. To do away with the need for this readjustment as far as possible, and to be able, unless for very strong currents, to read the current in amperes at once, I have recently devised the instrument represented in Fig. 2, and which may be called a solenoid galvanometer.

It consists of a hollow bobbin, round which a length of insulated copper or German silver wire is wound, constituting the solenoid. The bobbin is placed with its axis vertical, and a hollow cylinder of thin soft iron is placed so as to be free to move vertically with its axis, connecting with that of the solenoid. This iron cylinder or core is suspended from the lower end of a spiral spring, the upper end of which is attached to the top of a tube movable up and down by a rack motion in a fixed exterior tube, which it accurately fits. When no current passes through the solenoid, the weight of the iron cylinder is so adjusted relatively to the extension of the spring that it hangs with a certain part of its length (about a third) out of the hollow of the solenoid. This position is determined accurately by two fine black lines on a white surface, drawn round the iron cylinder, about one centimetre from its upper end. These lines are viewed by means of a line through a vertical slit in the exterior brass tube, across which a fine wire is stretched. When the fine wire is seen exactly between the two black lines, the cylinder is in its zero position. When in this position the lower end of the tube, to the top of which the spiral spring is attached, has the zero point of the vernier, which it carries, opposite the zero point of a vertical millimetre scale. To adjust these two zero points (which requires to be done only once for all) a fine screw is provided whereby the top attachment of the spiral spring can be raised or lowered a little as required.

When the current to be measured passes through the solenoid the soft iron cylinder is sucked in by the electromagnetic attraction. It is then raised against this attraction by the extension of the spiral spring till the black lines are seen in their zero position. The number of millimetres through which the spiral spring has been extended shows by reference to a table the current strength in amperes. For greater convenience another scale placed opposite the millimetre scale shows at once the current in whole amperes, the fractions of an ampere, when required, being got from the table and millimetre scale.

The graduation of the instrument requires to be done with particular care, but it is obvious that when once one has been done to serve as a standard all others can be very easily and speedily graduated from it.

The graduation may be effected by the tangent galvanometer, the electrolysis of water, or any of the ordinary methods for determining the strengths of an electric current. I have employed both the former methods, in order that the one might serve as a check upon the other, but have relied chiefly, especially for strong currents, upon the method by the electrolysis of water. In graduating by this method the instrument is placed in circuit with a Grove battery, and a suitably constructed water voltameter. In the same circuit is included a rheostat arrangement, where, by varying the resistance in the circuit, currents varying very little from each other in strength can be readily obtained. Having adjusted the current to suit any particular division of the millimetre scale, the mixed gases from the voltameter are collected by displacement in a glass vessel of known capacity, usually 50cc. or 250cc. or 1,000cc. The time taken to fill this vessel is accurately observed by a stop watch, and, at the same time, the temperature and height of the barometer noted. From these data the current strength

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corresponding to that particular division of the millimetre scale is calculated from the formula

$$C = \frac{V \times 273 \times P}{\cdot 1764 \times t \times (273 + \theta) \times 760},$$

where

C = current in amperes.

P = atmospheric pressure in mm. of mercury.

t = time in seconds.

θ = temperature in degrees centigrade.

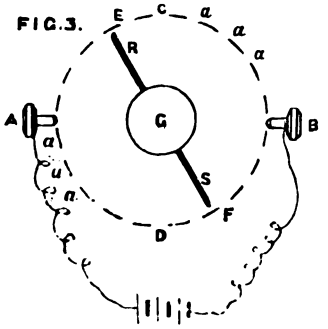
During the entire process of graduation a separate adjustable resistance is provided whereby the current strength is kept constant during the time of making an observation, although that time was never so long as to allow of any great variation in the current strength. In this way the instrument has been graduated from 0 up to 24 amperes.

From measuring stronger currents three arrangements may be adopted. These are:—(1) The use of a stronger spiral spring retaining the same solenoid and core. (2) Retaining the same spring and core, but sending the current to be measured through one only or any combination of the coils of the solenoid. (3) Shunting a known fraction of the current past the instrument.

To the first of these methods there are several obvious practical objections, and hence it has not been employed in any of the instruments as yet constructed.

For employing the second method a set of separate terminals is provided whereby the current can be sent only through the first, second, third, &c., or any combination of the solenoid coils. These terminals are numbered, and a reference to a table shows at once, in the column appropriate to each number, the current corresponding to any number of millimetres.

FIG. 3.



For employing the third method a set of separate resistance coils is provided, each having exactly the same resistance as that of the measuring solenoid. To secure this each is made of exactly the same length of the same wire as that surrounding the solenoid. When one coil is employed as a shunt the current indicated by the instrument has simply to be multiplied by two, when two are employed in multiple arc by three and so on. This form of shunt arrangement, although very accurate, has the disadvantage of rendering the instrument less compact and more unportable than is frequently desirable. To avoid this as far as possible I have adopted a second form of shunt arrangement which depends upon the principle of Wheatstone's bridge, and which will be readily understood from Fig. 3.

A C B D is a massive ring of brass or copper surrounding the sole-plate of the instrument, A and B being the terminals at opposite ends of a diameter by which the current enters and leaves the ring. At equal distances round the ring twenty gaps, a, are made, each of which is bridged by a wire having a known resistance which may be represented by a. G represents a horizontal section of the solenoid coil, which is supported on a vertical pivot passing through the sole plate. To the lower end of this pivot a horizontal arm is attached whereby the solenoid can be rotated through a right angle. Two projecting arms of brass, R and S, are rigidly attached to the opposite sides of the case of the solenoid. These are insulated from the case, but are in metallic connection with the ends of the solenoid wire. When the solenoid rotates, the outer ends E and F of the arms R and S make tight slipping contact with the metal ring A C B D. If a current, X, enter at A and leave by B, and if E and F be placed so that the line through E G F coincide with the diameter C D of the ring, it is obvious that no current passes through the solenoid. Let it be placed as shown in Fig. 3, so that there are seven gaps in the arcs B E and A F, and three in the arcs at E and B F, and let g be the resistance of the solenoid. By an easy application of Kirchoff's laws it can be shown that, if X be the main current, and C that in the solenoid G,

$$\frac{X}{C} = \frac{7a + 3a + 2g}{7a - 3a} = \frac{10a + 2g}{4a}.$$

Hence

$$X = \frac{10a + 2g}{4a} \times C.$$

The value of C is given at once from the millimetre scale, and X is formed by multiplying by the factor $\frac{10 + 2g}{4a}$. It is obvious that for all positions of the arm E F the numerator of this fraction is the same, and that for any position the denominator is the difference between the resistance in the arcs B E and E A respectively. Hence the reduction factor can in all cases be easily obtained.

The solenoid voltmeter—an instrument for determining the difference of potential between any two points of an electric circuit—is constructed exactly on the same principle as the solenoid galvanometer. The only essential difference between them is that in the voltmeter the solenoid bobbin is surrounded by a great number of turns of fine insulated copper or German silver wire, so as to have a great resistance, not less than 5,000 or 6,000 ohms.

The object of making the resistance so great is that, when the instrument is joined up as a shunt to the main circuit between the two points whose difference of potential is to be measured, it may not sensibly diminish that difference. The voltmeter is graduated in the same way as the galvanometer, and shows by reference to a table the difference of potential corresponding to the various divisions of the millimetre scale.

ELECTRO PULVERISER AND AMALGAMATOR.

The Manes electro pulveriser and amalgamating machine, shown in the cut, is designed for saving the rusty and fine gold, also the quicksilver, that has been lost in hydraulic washing for gold on the coast of California ever since the commencement of hydraulic washing in the summer of 1852. It is said that the loss has been at the rate of from 20 to 35 per cent. of the precious metals and mercury, which, if saved, would amount to hundreds of millions of dollars.

Notwithstanding all the modern improvements in mining machinery, immense quantities of the precious metals are constantly washed away and irrecoverably lost. The value of this lost portion, according to various estimates, is very nearly if not quite as great as that of the metal secured. A great deal of engineering skill and inventive genius have been engaged in trying to devise means of preventing this great loss. This has generally resulted in placing various devices in the sluices to catch and retain the stray particles of gold or sulphuret. Some of these inventions have been more or less successful, but none of them have saved anything like a reasonable proportion of the valuable part of the metals.

The electro amalgamator, it is claimed, will save from 50 to 75 per cent. of all the gold and quicksilver that passes through the machine, as the rusty gold will be perfectly scoured and electroplated with quicksilver, and thoroughly amalgamated by the rapid action of the electrical steel brushes and steel mullers that revolve inside of the series of steel cylinders in the machine, placed one above the other, and made cone shape, and connected with spouts; the large end of one cylinder is placed under the bottom of the small end

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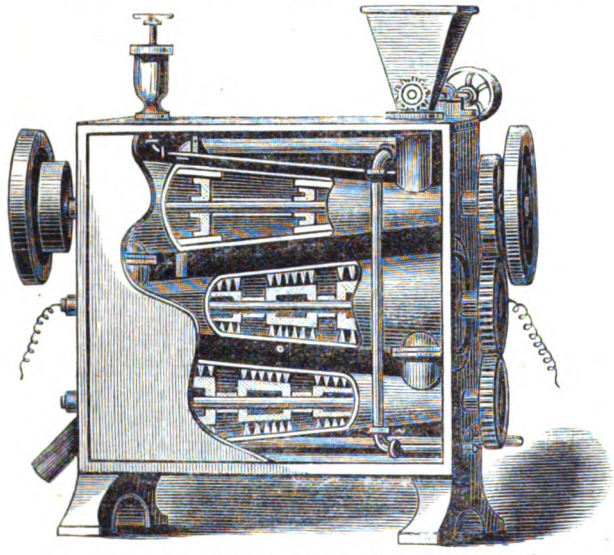
of the next one, and so on, forming inclined planes for the sand or crushed ore to run down by its own gravity, which is assisted by streams of water and quicksilver, constantly fed into the machine from a hopper on the upper part of the machine; and the powerful current of electricity is constantly passing through the sands or ore, as it passes from one cylinder to another, and as it is thoroughly mixed at the same time with the quicksilver by the steel brushes, no gold escapes without having been thoroughly amalgamated. The material passes through a movable iron spout into settling tanks, where the cleaning up is done. The machine does not stop except when repairs are needed; the waste water of the sluice boxes is used for driving the machines, and but one



Manes' Electro Pulveriser and Amalgamator.

man is required to attend to each machine. The fine sands will be conveyed into the machines through screens of the proper size. This apparatus can be used in stamp mills for amalgamating purposes, and will surpass the old process of treating gold and silver ores. The inventor, Mr. James Manes, is now engaged at the new chemical works in Morrison, Jefferson County, Colo., for the Colorado Paint and Chemical Company, as chemist and metallurgist. Mr. Manes, as an inventor of mining machinery, is well known in this and other countries. The first one of the electro amalgamating machines has just been completed at the extensive shops of the Colorado Iron Works, Denver, Colo., and the models and complete drawings are exhibited at the office, 5, Windsor-block, Denver, Colo.—*Scientific American.*

ELECTRIC LIGHTING OF NOTTINGHAM.

Specification and Tender No. 1.—60,000 Lamps.

General Nature of the Installation.

The installation to consist of the necessary mains, machinery, reserve machinery and buildings, as specified below, for the continuous supply of a current of electricity to all the houses, warehouses, shops, factories, street lamps, &c., in the district marked on the map sent herewith, sufficient for the maintenance of 60,000 (sixty thousand) Swan lamps of 20 candle-power* each during 16 hours out of the 24, and of one-third of that number during the remaining eight hours.

Electromotive Force.

The current to be supplied at an E.M.F. of not more than 70 volts, and so that the Swan lamps can all be arranged "in quantity."

The Dynamos.

Five Gordon dynamos to be provided, four to work, one spare, each being capable of continuously maintaining 15,000 Swan lamps of 20 candle-power each for sixteen hours out of the twenty-four, when running at a speed not exceeding 150 revolutions per minute.†

The magnets to revolve, and the current to be taken off directly from the fixed armature coils without rubbing contacts.

The dynamos to be connected direct to the engines without belts.*

The Exciters.

Six sets of direct current machines to be provided to excite the magnets of the large dynamos, one set to be used for each dynamo, and one to be in reserve, so that it can be instantly connected to any one of the dynamos in case of its own exciter getting out of order.

The Engines (for the Large Dynamos).

Each dynamo will require when working all its lamps about 1,530 I.H.-P.

Two engines to be provided for each dynamo, to be coupled one to each end of the shaft. Each engine to be capable of developing 850 I.H.-P. Thus, ten engines in all are to be provided for driving the large dynamos. The engines to be compound, condensing, tandem, of the vertical inverted cylinder type. They are each to have one high pressure cylinder on the top of one low pressure cylinder, one piston rod carrying both pistons. They are specially designed for electric light work, with extra large crank shafts and bearing surfaces, and special methods for lubricating all parts without stopping. They are to be fitted with the best governors that can be obtained, and are to be in all respects capable of running at 150 revolutions per minute for sixteen consecutive hours in each day without ever stopping. They are to work at a pressure of 100lb. per square inch.†

The Small Engines (for the Exciters).

Six small engines to be provided for driving the exciters, each to indicate up to 60 H.-P.‡

These engines to be also compound, but will not have separate condensers; they are to be connected to the condensers of the larger engines.§

Boilers.

Thirty-eight flue-boilers, fitted with Galloway tubes, to be provided, capable each of developing about 220 I.H.-P., so that thirty of them may be at work and eight idle. Patent automatic steam-stoking apparatus to be provided, as also all the usual gauges, &c.

Steam Pipes and Connections.

All necessary steam pipes and connections to be provided.

Provision to be made for shutting off any boiler or any engine as required, and for removing any pipe without stopping the supply of electricity.

The Engine House, Boiler House, Coal Store, and Chimney.||

The general arrangements to be as shown in the tracing sent herewith.

Adjoining the boiler house is to be a store for 1,000 tons of coal (about three weeks' winter supply). The floor of the store is to be above the level of the boilers, so that the coal, after being placed in it, will not have to be lifted again. A 4-ton power-hoist and raised tramway is to be provided for filling the store. Arrangements are to be made so that the coal is discharged from the store into trucks running on tramways above the level of the boilers and discharging into the hoppers of the mechanical stokers. Another tramway, on a lower level, is to be provided for the removal of the ashes, and is to carry them to the bottom of the hoist above mentioned, which will lift them to a convenient height for discharging into waggons.

In the engine house is to be a gallery containing the regulating rooms.

The design for the exterior of the building to be subject to the approval of the corporation.

The corporation to provide the site and to bring to it a suitable water supply, and to provide for the removal of the waste water.

The Traveller.

A 20-ton power-traveller to be supplied and fixed in the engine

* Mr. Swan is now making lamps of 40 and 100 candle-power (for street lighting, &c.) which can be used with the 20 candle-power lamps. They take the current of two and five 20 candle lamps respectively.

† It will be seen that this allows ample provision for maintaining 60,000 lamps all night, and a smaller number in the day, the supply being continuous.

* These dynamos are excessively strong, the revolving parts being built up of wrought-iron plate. The total weight of each dynamo is about 45 tons.

† These engines are extremely economical of coal, and are practically silent.

‡ The use of separate engines for the exciters enables the current to be regulated by varying the speed of the small engines, and without the waste which would be involved if the regulation were done by the introduction of resistance.

§ Thus, when all the 60,000 lamps are at work four dynamos and four exciters will be in use, requiring in all 6,360 I.H.-P.

|| The Telegraph Construction and Maintenance Company would prefer to do the whole of this work, and not to have it done by the corporation as at first proposed. It is included in the price given below.

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room, so that it can lift any portion of the engines or dynamos that may at any time require lifting.

Regulating Apparatus and other Fittings.

The following fittings and regulating apparatus to be furnished:—

Eight photometers, 6 ammeters, 10 volt-meters, 8 registering volt-meters, 5 strophometers, 5 steam gauges, switches and slow motion levers to exciting engines.*

Suitable plug boards for varying connections of dynamos and removing defective coils.

All suitable apparatus for rapidly substituting one large dynamo for another in a circuit, and for substituting one exciter for another.

Foundations and Fixing.

All necessary foundations to be built, and all the boilers, machinery, &c., to be properly fixed.

The Mains.

The mains to consist of copper rods of not less than 96 per cent. conductivity, efficiently insulated and enclosed in iron tubes, separate tubes being provided for the line wire and for the return.

The section of the copper is to be such that when any portion is carrying the full current for the number of 20-candle Swan lamps that it is specified to carry, such current shall not exceed 1,750 amperes per square inch section of copper.

All necessary junction and testing boxes to be provided.

Laying the Mains.

The mains to be laid underground, as shown on the map sent herewith. The figures on the map are the number of lamps proposed for each house and block, but are subject to any reasonable modification, the total being kept the same. Each machine has two circuits, so the four working machines supply eight circuits in all.

There are four sets of lines (A, B, C, D) on the map, radiating from the engine house; each line represents two circuits (or four conductors).

The two circuits shown by the same line are to be connected to different machines, so that every house has half its lamps supplied from one machine, and half from another, and so that in case of any machine being temporarily stopped from any cause, no single house will be placed in darkness.

All these mains and branches to be laid and fixed, and two pairs of poles brought into each house, as shown on the plan, and all streets to be made good again.

Working Thirty Days.

As soon as all the above work is complete, and also the fixing of the lamps in the houses (or a reasonable proportion of them to be approved by the corporation), the machines to be started and a supply of electricity provided for thirty consecutive days and nights, such supply being sufficient for 60,000 lamps (or such less number as may be approved by the corporation) from sunset to sunrise and for 20,000 from sunrise to sunset, an intermission of fifteen minutes being allowed in each circuit twice between sunrise and sunset, but the intermissions in the two currents supplying any one house are never to coincide.

In case of any weakness, defect, or imperfection showing itself during these thirty days, the Telegraph Construction and Maintenance Company are to repair it. At the end of thirty days' satisfactory trial, they shall be held to have completed their undertaking. The Telegraph Construction and Maintenance Company to supply coal, oil, and labour for the trial; but the corporation to supply water—all rates and taxes chargeable on the works while in progress to be paid by the corporation.

If, at the completion of all the work except the thirty days' trial, there shall not be in the opinion of the corporation a sufficient number of lamps erected to render a satisfactory trial possible, the corporation may direct the commencement of the trial to be postponed for a period of not more than two months; but, in the event of their directing such a postponement, then (in addition to the price agreed upon) interest is to be paid by them at the rate of 5 per cent. per annum on the amount of the payment which falls due at the end of the thirty days' trial, such interest to count from the date of the completion of the work to the date of the corporation giving permission to commence the trial.† No such interest, however, shall be claimed if the Telegraph Construction and Maintenance Company have been employed to erect the lamps and internal fittings, and if the delay is caused by any fault of theirs.

General.

The whole of the work is to be finished in the most complete and careful manner.

Price.

The price to be paid by the corporation to the Telegraph Construction and Maintenance Company for the whole of the above work to be two hundred and twenty thousand pounds (£220,000).

* The ten volt-meters (two to each dynamo) enable the workman in charge of each dynamo to keep the electric pressure constant. The eight registering volt-meters (one to each circuit) inform the manager in the morning of any variation of pressure which may have taken place during the night. The strophometers show the speed of the large engines; the ammeters show the strengths of the exciting currents.

† A good trial can be obtained as soon as 15,000 lamps in all are erected, as the eight circuits can all be temporarily connected into two and attached to each one of the dynamos in turn.

Appendix.

Estimated Working Cost for 60,000 Lamps.

The following figures are given for the information and convenience of the corporation. It is believed that they are correct, but they are not in any way guaranteed:—

	Per annum.	Per annum.
All the lamps working 2,500 hours per annum.		
Depreciation and repairs (noting that ⅕ the machinery is idle)		£10,000
Coal:—		
For 6,360 H.-P. for 2,500 hours, at 2¾lbs. of coal per I.H.-P. per hour. 19,370 tons, which at *10s. per ton makes		9,685
Oil, waste and petty stores		830
Labour:—		
†Electrician's Department:—		
One chief electrician	£350	
Two assistant electricians at £150	300	
Four workmen at 26s.	270	
Engineer's department:—		
One chief engineer	350	
One assistant engineer	150	
Each shift—To each dynamo, one engine driver at 35s., one labourer at 25s., one dark room man at 30s., four dynamos at work make £18 per week, or £936 per annum. Three shifts of eight hours each ‡ (men of day shift to do all cleaning and assist in minor repairs)	2,808	
§Firemen:—		
To attend to the boilers, which are fired mechanically—		
Two chief firemen at 45s.	236	
Assistant firemen at 28s.—		
First night shift to attend to 30 boilers, 6 men	875	
Second night shift to attend to 20 boilers, 4 men		
Day shift to attend to 6 boilers, 2 men		
‖Repairing shop:—		
Two fitters at 40s. and 35s.; one labourer at 25s.	260	
Total labour		5,393
Water rate		500
Other rents, rates and taxes		500
Office expenses		500
Renewal of Swan lamps, at 2s. per 1,000 lamp-hours on 60,000 lamps for 2,500 hours		15,000
Total annual expenditure		£42,608
Cost of Gas:—		
60,000 gas jets (of 12 to 14 candle-power each), each burning five cubic feet per hour for 2,500 hours, burn 750,000,000 cubic feet, and with gas at 2s. 6d. per 1,000 cubic feet, cost		£93,750
If the consumers are charged the same for each Swan lamp as for each gas burner, this gives us		
Revenue		93,750
Expenditure		42,608
Profit		£51,142

to pay a dividend on a capital expenditure of £220,000, which is equal to 23$\frac{3}{16}$ per cent. per annum.

* Good steam coal is here supposed to be used, but the boilers specified will burn slack coal, which is cheaper.

† The labour required for repairs in the houses is not counted here as the house owners requiring it will be charged with it.

‡ Here each man will work 56 hours per week of seven days.

§ Note that with the coaling arrangements shown in the drawing of the boiler house the coal is delivered mechanically, direct from the store into the hoppers of the steam stokers.

‖ For minor repairs only. Large repairs are included in the item "Depreciation and repairs, £10,000."

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If the corporation wished to make only six per cent. per annum they could supply the electricity (lamp for lamp) at the same price as gas, at less than 2s. 6d. per 1,000 cubic feet, as follows :—

6 per cent. on £220,000 =	£13,200
Working expenses.....	42,608
Required annual revenue.....	£55,808

Thus would be obtained from 60,000 gas jets burning 750,000,000 cubic feet per annum with gas at 1s. 6d. per 1,000 cubic feet.

Summarising these Results, we have

	Lamp of	Cost per hour to the Consumer.
Gas at 2s. 6d.	14 candles	·149 penny
	20 candles	·212 ,,
Electricity to pay 6 per cent., 20 candles		·090 ,,

If instead of each lamp (gas or electric) burning 2,500 hours per annum, two or three burning alternately make up the 2,500 hours, the above result will not be altered, the electricity and gas being alike supplied by meter.

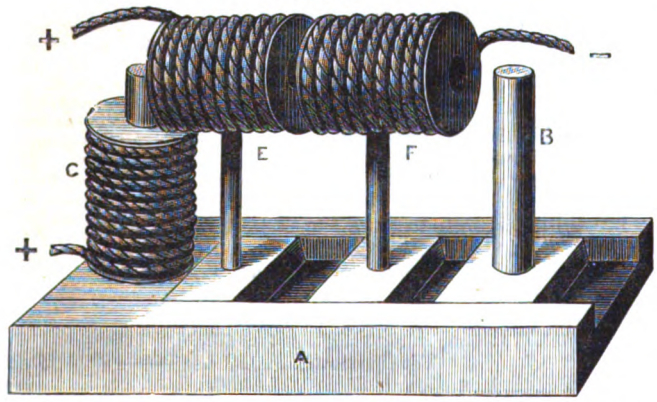
MAGNETISM.

BY JOHN T. SPRAGUE.

(CONTINUED FROM PAGE 539.)

18. *Needles for Galvanometers and Compasses* may be very well magnetised in the apparatus shown (Fig. 13), which carries out the principles just explained. A is a base of iron, with sides to form a slide frame. B is the core of an electro-magnet, mounted on an iron base, sliding on A. A similar core of C can be fixed

FIG. 13.



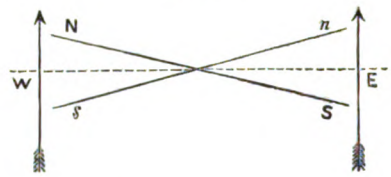
Iron base, A. Fixed electro-magnet, C. Core of sliding electro-magnet, B. E F, electro-magnets on sliding feet.

in A direct, and is shown with its coil mounted. E and F are electro-magnet coils, carried on sliding bases, so that they and B can be adjusted to the length of any bar to be magnetised. The wires of C and B are to be connected together as usual to carry a steady current. The ends + and − of E and F are similarly connected, so as to divide the current with C B. The middle ends are to be connected to a break, or one may be joined to a file, and the other run along it, so as to set up intermittent currents in this part of the system. The coils E F are made in two for the purpose of inserting mounted needles or pairs of needles.

19. *Astatic needles* are pairs with their poles in the opposite directions ; they can be magnetised in the apparatus just described by reversing the direction in which the needles are placed in E.F. If the two needles are exactly alike, and perfectly truly mounted, such a system has no directive power in the earth's field, but will place itself in obedience to any external agency, such as torsion, and would range itself at right angles to a wire between the pair, however feeble the current in the wire. It is usual to give a slight directive force by leaving one needle slightly stronger ; in any case the needles cannot long remain equal, as if one is inside a galvanometer coil, as usual, and the other outside, the inner will receive stronger magnetic impulses ; and, if unequal, the one whose position in the earth's field is reversed will lose magnetism.

20. It is commonly taught that such astatic systems will place themselves east and west, and some books furnish a very elaborate mathematical reason for this. Neither the statement nor the explanation is correct. If two needles are very closely equal they sometimes range themselves east and west, and Fig. 14 will explain the reason. The two needles are not exactly in the same plane ; the figure, of course, exaggerates the error of adjustment to exhibit the effect. N S and *n s* are the two opposed needles. Now it is evident that they produce two magnetic fields, N *s* and *n* S having the same direction as the earth's magnetic field shown by the middle arrow. Hence it is a misstatement of the facts to say that the needles place themselves east and west. The needles have no directive action because they neutralise each other, but *their external fields* unite to form two parallel fields shown by the arrows, and these fields unite with the earth's field and place themselves in the usual direction, of course carrying the

FIG. 14.



neutralised needles with them, and as an incident causing them to lie in the east and west direction.

21. *Quality of Steel.*—Some authorities say that for large magnets hardened cast steel is best ; for compound horseshoe magnets the same steel annealed at 500°, or hard shear steel ; for needles, cast steel annealed in boiling oil. Steel made of the best iron, such as Swedish, makes the best magnets ; but it is very doubtful if *cast* steel is adapted to the purpose. It is now found that the presence of about 3 per cent. of tungsten (wolfram) endows steel with high magnetic power ; this steel is manufactured at the Allevard works in France, and is now employed for high quality magnets by many makers, but it is rather costly.

Cast iron will also take permanent magnetism ; it should be of a quality containing little carbon, known as white iron, and is improved by the addition of 10 per cent. of steel ; it should be tempered or rather hardened at a high temperature, and it is not unlikely that the best process would be that known as "chilling," that is, casting in cold iron moulds. Attempts have been made to magnetise both cast iron and steel by a current passed while in the act of solidifying, but the result is to produce hollow castings. The moulds may also be placed in a powerful magnetic field, but it is very doubtful if the result would repay the trouble and expense.

By care in selection of metal, and in magnetising, bar magnets have been produced carrying 20 times their weight, and horseshoes 40 to 50 times their weight.

22. *Form and Arrangement.*—For compass needles the best form is flat, tapering from the middle to the points. For bar and horse-shoe magnets the mass of material should be divided into a number of plates not exceeding a quarter-inch in thickness, separately tempered and magnetised, and arranged with their similar poles together. They should be insulated from each other by sheet brass or cardboard, and bound together by screws or external bands of brass, and in some cases it is well to terminate the whole by pieces of very pure soft iron, shaped as desired, fitted to the end of the bars, and secured to them.

Very powerful magnets have been made of late from very thin steel plates similar to that used for clock springs, with the ends gathered into terminal blocks as just mentioned. These, which are called "Jamin's" magnets, are much used for small dynamo machines, fuze exploders, and similar apparatus.

When several bars are thus united the total force is never equal to the sum of the whole separately, because the similar poles tend to neutralise each other ; in some cases the central bars will even be reversed by this action, for which reason they should be the longest. This is the reason, together with the superior temper of the metal and more complete penetration of the magnetism, that a number of separate pieces give more power than a solid bar of the same mass, as in this the interior portions are apt to take reverse magnetism to the exterior, thus completing closed magnetic circuits, and leaving little force to be exerted on external objects.

23. *Preservation of Magnets.*—They should be carefully handled, and all jarring actions avoided ; when not in use needles should be placed in the true magnetic direction ; the same with bars ; but either may be still better preserved by placing two together with their poles reversed, and a small piece of soft iron between

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them at each end. Horse-shoes should always have the keeper or armature on, and their powers may be greatly increased by hanging them up with a weight attached, which can be gradually increased. Care should be taken, however, never to violently detach the keeper, and when this is removed for use, it should be done by sliding it off across the poles, not by pulling it away.

24. The power of a magnet is influenced by its surroundings, such as neighbouring magnets and currents, and also by temperature; a strong heat demagnetises steel, and the magnetism even lowers with an ordinary rise of temperature, increasing again as temperature lowers. It is also found that a flash of lightning, even though distant, affects the magnetic force, showing how intimately connected all nature is. M. Marcel Deprez (the construction of whose galvanometers renders the question of constancy important to him) asserts that magnets do not vary in their intensity by lapse of time, and has described some interesting apparatus and experiments in proof of this; but general experience does not agree with him.

25. *The earth itself is a large magnet*, and this is the reason that the magnetic needle has an apparent directive power, because it places itself on the lines of the earth's magnetic field. Terrestrial magnetism is a subject by itself, and one of vast practical interest, but it will be treated in these articles only so far as to regard the earth as a huge magnet, and to understand that its actions are the same as those of any other magnet. The poles of the earth's magnetism are not coincident with its axis of revolution, nor are they permanently fixed; hence the *variation of the compass*, which varies according to some definite but as yet unknown law. It appears as if there were two magnetic axes (that is, two N and two S poles), which make a slow revolution around each other, while this compound axis also revolves around the polar axis of the earth in a period of about 320 years. At present the position of the magnetic poles is

North pole. Latitude 77° 50′; Longitude 63° 31′ West.
South „ „ 77° 50′; „ 116° 29′ East.

26. The *variation*, or declination, besides this general change about 7′ per year in England and now amounting to 18° 25′ to the westward and diminishing, has annual and daily small variations, due apparently to the electric currents generated in the earth by the variations of temperature.

27. The *intensity or force* is subject to similar variations, caused partly by the change of position of the poles as regards each part of the earth, which at present slowly increases the force in England, and partly by the fluctuations in the causes of magnetism itself, which probably are connected with periodical changes occurring in the sun, and the maximum and minimum periods of sun spots, and also probably with the grouping and relative distances of the planets. Irregular variations accompany displays of aurora.

The force is considered under two heads.

28. The *dip* or vertical component is the intensity of the attraction with which a perfectly balanced needle is drawn out of the horizontal line with its end dipping towards the nearest magnetic pole, where it would assume the vertical position. The practical effect is that a magnetised needle requires a counterpoise to balance this force if it is intended to rest in a horizontal plane.

29. The *horizontal intensity* is of the most importance, as in galvanometers the value of a deflection produced by a current is proportional to the horizontal intensity of the earth's pull on the needle at the place of observation, which varies from a maximum at the magnetic equator to nothing at the pole; its position of greatest intensity is in latitude 0°, longitude 101° west, where it equals dyne ·3733. At Greenwich its value was

	Dynes C.-G.-S.	Metric M.-G.-S.
1848	·1716	1·716
1873	·1791	1·791
1875	·1794	1·794
1881	·1805	1·805

An approximate formula for ascertaining the value at different parts is given by Biot as $\sqrt{1+3\sin^2\lambda}$, where λ is the magnetic latitude or inverse angular distance from the magnetic pole.

Another formula is based upon the assumption that the earth is a uniformly magnetised body, or that it acts as the magnetised field generated by a magnet at its centre; the magnetic moment, section 32, gives ·33092 × sin λ.

(TO BE CONTINUED.)

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1, 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

ON THE INFLUENCE OF SURFACE-CONDENSED GAS UPON THE ACTION OF THE MICROPHONE.*

BY I. PROBERT AND ALFRED W. SOWARD.

One of the theories advanced to account for the action of the microphone states that the layer of air between the microphone surfaces acts as an ordinary resistance, that the effect of sonorous vibrations is to cause the carbons to approach, and to recede from, one another, and so to alter the thickness, and consequently the resistance of this interposed layer. This variation of resistance produces the variation of current essential for the reproduction of sound.

There is in physics a phenomenon known as heterogeneous adhesion, one phase of which is the surface condensation of gases. A study of this phenomenon shows that every surface exposed to a gas is coated with a condensed layer of that gas. The more readily the gas is liquefiable by pressure the greater is the quantity condensed, and in the case of the very readily liquifiable gases the exposed surface is actually coated with a layer of liquid.

Our atmosphere, as is well known, consists mainly of nitrogen, oxygen, carbon dioxide, and water vapour. Careful experiments with charcoal (a substance which, owing to its porous nature, possesses a very large surface relatively to its mass) show that the coefficients of surface condensation of these gases (that of hydrogen being taken as unity) are 3·5, 4, 15, and 80, respectively. These figures multiplied by the figures representing the proportions in which the gases exist in the air, viz., 79, 21, ·03, and, say, 1·5 give the proportions in which the substances exist in the condensed layer. They are:—Nitrogen, 276·5; oxygen, 84; carbon dioxide, ·12; and water vapour, 120. Of these four gases the first two, oxygen and nitrogen, would be condensed without liquefaction, and the effect of this condensation would be to slightly reduce the electrical conductivity of the layer, for it is known that the conductvity of a gas is reduced by condensation; the carbon dioxide would probably be liquefied, and the effect of its liquefication would be (slightly, on account of the small quantity acting) to increase the conductivity; the water vapour would certainly be liquefied, and the effect of its liquefaction would be to very considerably increase the electrical conductivity of the layer. The effect, then, of this phenomenon of surface condensation is to coat the microphonic surfaces with a layer of far better electrical conductivity than ordinary air.

In order to test the influence of this layer of condensed air upon the action of the microphone, we have lately made some experiments with the instrument in different gases. The gases used were hydrogen, carbon dioxide, wet air, and dry air; and our method of experimentation was as follows:—A microphone of a well-known pattern, consisting of a glass tube containing cylindrical carbon blocks, and having many contact surfaces, was attached to the inside of a clock case and placed in circuit with a Hughes audiometer, a Morse key, and three Leclanché cells. The carbon blocks of the microphone were pressed well together, so as to avoid as far as possible alteration of contact due to chance vibrations. A current of air, dried by passage over pumice stone soaked in strong sulphuric acid and then over peroxide of phosphorus, was urged through the microphone for half an hour. The resistance of the microphone was then measured, and the point of the audiometer scale determined at which the beating of the clock became inaudible in the telephones. A current of similarly dried hydrogen was then passed through the microphone for half an hour, and the resistance again measured and the point of silence determined in the audiometer. The experiment was next repeated with carbon dioxide, the dried gas being passed through the microphone for a similar period; and, finally, for fifteen minutes a current of air was forced through water contained in a Woulffe bottle (in order to load the air with water vapour) and then through the microphone. The resistances and points of silence in the audiometer were determined as before. Our results are expressed in the following table, and it may be noted that the scale of the audiometer was graduated 0° in the centre to 100°:—

Name of gas.	Resistance of microphone in ohms.	Point on scale of audiometer at which silence was reached.
Wet air	386	51°
Carbon dioxide	435	56°
Hydrogen	600	58°
Dry air	520	63°

It will be seen that the best result was obtained with wet air, which, calculation shows, should give a good conducting surface layer. Next in order is carbon dioxide, which, in the liquid state, is a moderate conductor. Hydrogen comes next, as would be expected, for neither it nor dry air is reducible to the liquid state by ordinary surface condensation, and the best result is to be looked for from the less condensable of the two—that is, hydrogen. The resistance of the hydrogen-charged microphone is, however, anomalous.

In order to obtain our layers of condensed gas we considered it sufficient to pass a stream of the desired gas over the microphone for some time, because it is known that when a piece of carbon charged with one gas is placed in an atmosphere of another, the two gases diffuse into one another, with a result that the carbon remains charged with a mixture in the proportions indicated by multiplying their percentage volumes by their respective condensation coefficients. In our experiments the quantity of gas passed through the microphone in any one experiment was vastly greater than the residual gas from previous experiments.

We did not attempt to rigorously exclude water in any of our experiments, for it has been shown that the last trace of water so obstinately clings to a surface that to perfectly dry a glass tube it must be raised to the softening point, and so kept for some hours, while a stream of dry air is urged through it.

In these experiments with different gases there is a possible source of error which must not be overlooked. We have elsewhere shown (*The Electrician*, Vol. X., p. 496) that the resistance of a piece of porous carbon is not

* Read before the Society of Telegraph Engineers and of Electricians on Thursday, April 12, 1883.

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a constant for a given temperature, but varies with the chemical nature and with the density of the gas with which the pores of the carbon are filled. It follows from this that if a constant electromotive force be used the current flowing and the sounds obtained will be altered by any alteration in the nature of the gas absorbed in the body of the microphone irrespective of the contact surfaces. But the carbon used for our microphone had very little absorptive power, and its resistance was practically constant at constant temperature.

We think from these experiments it is fair to infer that the layer of condensed gas with which every microphone surface is covered is concerned to some extent in the regulation of microphonic action.

As bearing upon the effect of a layer of moisture we may notice the following experiment:—

A common tin canister, joined through a rheotome to one pole of a 4-cell Grove battery, and held in the hand by an insulating handle, was pressed against the ear; a wire attached to the second pole of the battery was held against the tongue. Sounds were heard corresponding to the working of the rheotome, and a burning sensation was experienced at the ear such as one might imagine would be produced by innumerable small electric discharges. Similar results were obtained with a 10-cell Daniell battery (chamber pattern). The surface of the canister, which, having been exposed to the air, was coated, as all similarly exposed surfaces are, with an invisible layer of moisture, was then well wetted. The burning sensation became more marked, but the sounds of the make and break were no longer audible. We may add that a solid brass ball, whether wet or dry, gave no sounds in this experiment.

THE SOCIETY OF TELEGRAPH ENGINEERS AND OF ELECTRICIANS.

Thursday evening, the 26th ult., was assigned to the discussion upon the several papers relating to microphonic contacts and the theory of the microphone read at the two previous meetings of this society—papers all of which have now been published in these columns. No fewer than three additional papers, however, were read on this occasion, and, consequently, the discussion proper was brief and limited. The first paper was a communication from Professor SILVANUS P. THOMPSON, in which he took exception to some portions of Mr. Shelford Bidwell's paper, chiefly relating to contacts of metal. The effects of loose contact, and of subjecting them to pressure were, Professor Thompson stated, well known ever since the early days of the telegraph, when binding screws were introduced, and when operators were instructed to make firm contacts with their working keys. In the second place Mr. Bidwell had not sufficiently investigated the range through which the current can be varied. He (Professor Thompson) had found that the available range of resistance, when metals were employed, varied with their conductivity. It was to be regretted that bismuth chiefly had been experimented upon by Mr. Bidwell, because that was, of all metals, the most unsuitable for testing their qualities as microphonic contact makers. Mr. G. S. Anders and himself had tested silver contacts in that way, and had found them not only less liable to deterioration, but more distinct than carbon, though the adjustment was more difficult because of the superior conductivity of the metal. And this was confirmed by the fact that carbons of best conductivity were best for microphones. He further pointed out that Messrs. Theiler, as well as Mr. Blake, had used metals for microphonic purposes before Mr. Munro. Reis also had used them, and although it was alleged that Reis had done so without knowing what he was doing, he, Professor Thompson, contended that Reis's instrument would transmit speech, and no carbon transmitter could do more than that.

Professor HUGHES offered a few observations to the effect that, although no doubt the theory now finding most favour for explaining the action of the microphone was correct as far as it went, it did not account for everything. For example, there was the fact first made known by a writer in the *Telegraph Journal* in 1880 that a sliding lateral contact would do as well as one of pressure—that is to say, a piece of carbon attached to the back of a diaphragm answered very well if it slided upon another carbon below it, instead of pressing against one behind it. He also stated that the microphone acted very well if you placed it in a glass of water and projected the voice upon the liquid surface. An arc theory accounted for much, and he accepted it to that extent. An electric arc had actually been made to transmit speech; but still he thought there were two classes of vibrations to be taken into account, and which had not yet been brought into harmony, the one a mechanical vibration such as resulted from the tapping of a block of wood, and the other an electrical vibration. A curious fact had come out in experiments made by Dr. Warren De la Rue and himself, namely, that with a weak power they had made a current to pass between two wires in a tube, nearly, though not quite, touching each other, whilst with a much stronger battery no current could be made to pass.

Professor AYRTON objected to the use of the term contacts in microphonic discussion, for, in reality, there were no contacts. Range as dwelt upon by Professor Silvanus Thompson had a good deal to do with the effects. The E.M.F. required was immensely greater for metals than for carbons, because the range is much less. For soft carbons much less E.M.F. was required than for hard carbons. He explained why a strong current would sometimes not pass when a small one would, by the circumstance that the energy exerted was sufficient to repel, and was expended in repelling the opposing points, and thus no current would bridge over the gap, at least none of sufficient duration to be perceived. On the whole he was led to the conclusion that microphonic elements were not in contact, and that in trying to account for their action we have to deal with an arc.

Mr. MUNRO then read a written supplement to his former paper, and argued that the objection taken by Mr. Bidwell to the metallic contacts applied to single ones, not to numerous ones such as were present in his, Mr. Munro's, gauze microphones. The new feature in this investigation was that of the repulsion of the contact points. He had illustrated this by freely suspending two carbons horizontally with their ends touching, and he now stated that when a current was sent through them they were seen, by means of a magnifying glass, to fly apart; they immediately fell together again, and were again repelled, the effect of which was that of a make and break contact, causing an incessant chatter of the telephone in circuit. Mr. Munro was understood to say, however, that metals do not appear to repel each other in this way. He also stated that a marked increase in the sound of his metal gauze microphone was produced by the approach of a magnet to their surface, diminishing perceptably as the magnet is gradually withdrawn. Lastly, he had caused to be made, and now exhibited, a microphone of his own pattern enclosed in a glass globe, the air from which had been exhausted. It acted perfectly well, and it could be regulated by means of a magnet from the exterior.

Mr. FAHIE then read a short communication, chiefly devoted to critical observations on the tables furnished in Mr. Bidwell's paper.

Mr. BIDWELL briefly replied, reminding the meeting that his paper dealt with facts the result of careful experiments; and that the criticisms directed against any theory he was supposed to be advocating were based on misapprehension. His paper was intended as a contribution of data that might assist in establishing an explanatory theory, but he had offered no theory of his own.

Mr. JAMIESON then exhibited and described a new electric current meter invented by Mr. Blyth of Glasgow; the usual votes of thanks terminating the proceedings.

WELCOME TO DR. NORVIN GREEN.

On Monday last a number of gentlemen, at the invitation of the directors of the European Atlantic Cable Companies, met to welcome Dr. Norvin Green, President of the Western Union Telegraph Company of America, now on a visit to this country. A commodious boat placed at the service of the guests started at six o'clock from the Westminster Pier for Greenwich, where, at the Ship Hotel, an excellent dinner was served. John Pender, Esq., M.P., presided, and among the guests present we noticed: William Abbott, Esq.; Arthur Anderson, Esq.: Kenneth Anderson, Esq.; G. Armitstead, Esq., M.P.; Hon. Evelyn Ashley, W. Barber, Esq.; C. H. W. Biggs, Esq.; C. Burt, Esq.; Viscount Bury, K.C.M.G.; G. Von Chauvin, Esq.; Mr. Coddington, Alexander Crum, Esq., M.P; W. S. Cunard, Esq.; Edward Dicey, Esq.; Henry Edwards, Esq., M.P.; Sir George Elliot, Bart., M.P.; William Ford, Esq.; L. Floersheim, Esq.; J. W. Fuller, Esq.; J. O. Green, Esq.; Dr. Norvin Green, J. G. Griffiths, Esq.; C. J. Gunther, Esq.; Admiral Sir Henry Keppel, G.C.B.; Hon. Mr. Keppel, M. le Comte de Lambertye, Mons. Lespinas, John Mackrell, Esq.; Mr. L. Maton, John Pender, Esq., M.P.; J. H. Puleston, Esq.; Dr. Pyle, Mons. Pouyer Quertier, M. le Marquis de Remy de Courcelles, Mons. Léon Riant, Professor Thorold Rogers, M.P.; E. M. Underdown, Esq.; Sir Hussey Vivian, Bart., M.P.; Sir Sidney Waterlow, Bart., M.P.; H. Weaver, Esq.; H. B. Weaver, Esq.; T. H. Wells, Esq.

After the toasts of "Her Majesty the Queen" and "The President of the United States" had been duly honoured,

Mr. FORD proposed "The Houses of Lords and Commons," coupled with the names of Lord Bury for the House of Lords and the Hon. Evelyn Ashley for the House of Commons. He said: I have been honoured with a request to propose the next toast. I do so with alacrity, because, according to the prophets of evil, the establishments forming part of the constitution of the country will soon cease to exist. Indeed, it may be that at the present moment a defeated majority may have succeeded in un-Christianising the House of Commons and rendering it less worthy of the respect of the people of this country. But, fortunately, I have to ask you to honour the House of Lords and the House of Commons as they are at present. I beg to propose "The Lords and Commons as at present constituted," coupled with those honourable names of Bury and Ashley.

The toast having been duly honoured.

Lord BURY, in response, said: My hon. friend, Mr. Ford, has proposed this toast with an invitation which is rather ominous. He proposed the Houses of Parliament as at present constituted. Well, I have always heard that there is a proverb that threatened men live long, and although I have heard that the House of Lords is to be abolished, I still think that it has a great deal of good work to do, and that it is not yet awhile to be abolished. Pending that day I return thanks for the kind way in which you have received the toast of the House of Lords. But when the evil day does come, and when the House of Lords is abolished, I made up my mind from the moment I heard the speech of my hon. friend that I shall apply for the post of electrician to the companies under the direction of my hon. friend on my right (Mr. Pender), so that I may be ready for the evil day when it comes [laughter]. I am a very good electrician, and Mr. Puleston knows that I am well qualified for that post. There is here at this table Mr. Munchbare who was my instructor in electricity, and he will tell you whether I am competent to test a cable, and many is the time that we have tested together in the pleasant room in which we are now sitting [laughter]. I am surrounded by the Nestors of electric telegraphy. I have no doubt that my hon. friend on my right has the thousand pound share which he subscribed, and which laid a cable in 1857 or 1858 not 100 yards from where we are sitting on the other side of the river. That cable was successful, and I may say that my hon. friend on my left (Sir George Elliot) was also a member of that association. That cable was a short lived cable, but it lived long enough to flash across the Atlantic two most important messages—one relating to the despatch of a British regiment, and the other relating to the crew of a wrecked British ship [hear, hear]. Those were the days when we were adventurers in the attempt to bridge the Atlantic by connecting England and America. I remember in those days it was thought a wonderful thing for the cable to be laid, and still more that one message should be passed: now messages increase day by day, and my hon. friend, the chairman, will give you extraordinary statistics which speak of the increasing number of messages across the Atlantic, and which unite the two nations in a bond of brotherhood impossible to be dissolved. From that day to this—from 1857-8 until now, as Mr. Pender has justly said, a vast work has been performed in telegraphy. Those whom Mr. Pender has brought around this hospitable board are the men who have done the work, and under these circumstances whether the House of Lords live long or live only a short time, I feel it an honour in responding to the toast of the House of Lords as they at present exist. [cheers].

The Hon. EVELYN ASHLEY, M.P., in replying for the House of Commons, said: One of the minor drawbacks in the otherwise great honour of

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being connected with an Administration is that we are called upon, in the presence of other and much older members of the House of Commons, who are fully as well entitled, if not more so, to return thanks for that House. The proposer of this toast has invited us to sing an elegy to a dying institution; but I am in no mood to do any such thing. I believe that though the difficulties of the House of Commons have been great, are great, and will be great in the future—that as long as the Anglo-Saxon race lasts representative institutions must last, and the House of Commons amongst other representative institutions. Now, the House of Lords has been very adequately responded for by my noble friend; and I would only remark with reference to what he says, that there is a great deal of electricity in the House of Lords; and there is no doubt that from time to time, with all their great merits, they do give us electric shocks in the Lower House; and what we must try to devise is some non-conductor to come between the two Houses, so that the effect may not be fatal to either House [laughter]. That is my fervent prayer and hope. Now, gentlemen, before I sit down I thank you for drinking the health of the House of Commons in so warm and enthusiastic a manner. I would just say, with reference to the general question of electrical communication, that though I have not that knowledge which the chairman has, I may say, as representing a department of some importance in this country, that I feel how impossible it would be, without the great electrical discovery of the present century, for the colonies of this country to be managed successfully. There is no doubt that evils arise from panic, scares, and electric messages sent more with sensation than truth, but the antidote is ready (except when the wire breaks, as Mr. Pender's did the other day at Zanzibar, but it was soon repaired), and we soon apply it. So far as the Colonial Office is concerned, they feel great gratitude for the discovery and the progress of electrical science throughout the world [cheers].

The CHAIRMAN then rose and proposed the toast of the evening, "Dr. Norvin Green and the Western Union Telegraph Company of America." He said: The toast that I have to propose now is the toast of the evening. But before I submit that toast to you, I beg to state that on account of indisposition there are several gentlemen absent this evening who would otherwise have been present. I refer to Lord Monck, Chairman of the Anglo-American Company, the Marquis of Tweeddale, a director of that company, Sir Daniel Gooch, also a director of that company, and to Sir James Anderson, also a director of that company, and whose name is so honourably associated with telegraphic enterprise. We have met here this evening, gentlemen, to do honour and to give a hearty welcome to my friend, Dr. Norvin Green [cheers]. This is the doctor's first visit to this country. It is the only thing that I have to find fault with the doctor for; but he has told me that for a long period of time he has looked forward to visiting England. He desired to come to England to find out something of the land from which he is an olive branch; for, gentlemen, in my experience of American travel, I find some of the most distinguished men there who love to look back to the old country, and to find that they are sprung from a noble root. The doctor is one of those distinguished men; and England is just as proud to have him as one of the branches as he is proud of claiming that his root was in England [hear, hear]. Gentlemen, the name of Dr. Green, as President of the Western Union Telegraph Company, of the United States, is a household word there. No man is more honoured than Dr. Green is in America. He fills the position which he occupies with very great credit and honour to himself. He has secured the confidence of the American people; and I can tell you that the position that he does occupy is one which requires not only the highest administrative ability, but, as president of that vast (I can scarcely find a word to express the omnipresence of the system over which he presides) undertaking, I say it requires not only high administrative ability, but the most unimpeachable honour [cheers]. Gentlemen, I think it is always well when speaking on an occasion like this that one should justify the opinion that you have formed and which you give of the man—I mean by statistics. These statistics apply to the institution over which he presides, and often—so very often as I have looked at telegraphic statistics—I have never been more struck than when I apply them to the systems of telegraphy in America. Let me put them before you, because it is well to have them in your mind. As I have mentioned, Dr. Green presides over a vast undertaking—a company with a capital of eighty millions of dollars. It has 13,000 stations scattered all over America; there are 20,000 *employés*; they have 150,000 miles of poles, and of wire on those poles 425,000 miles. There is no part either in the States or Canada where there is not a Western Union Station. Even in the very confines of the Indian reservation I found when travelling there the little blue sign of the Western Union Company. I may tell you that the car in which I was travelling was stopped by a little white flag, and a telegram was handed to me there; that telegram conveyed to me an evidence of the thorough organisation of the Western Union system; for when I left New York I was told, "You shall have every information in the shortest space of time." That telegram conveyed to me, about eleven o'clock in the day, news of Sir Garnet Wolseley's successful victory at Tel-el-Kebir. I had only time to reply congratulating him upon that victory, and I was told afterwards by Sir Garnet Wolseley that before the sun had set he had my answer [cheers]. Now, I say that that is a wonderful tale to tell. I found at every point we stopped at that this system, which I have already stated seemed to me to be omnipresent, showed that the progress of the Western Union Company was most marked. In 1866 there were 75,000 miles of wire and 2,250 offices. At the present time, as I have said, they have 425,000 miles of wire, 13,000 offices, and 20,000 *employés*. In 1866 the profits of the Company were little over two millions and a half of dollars. Now they are something like eight millions of dollars. The Company pays its shareholders a dividend of 7 per cent.; a share is worth something over 12 per cent.; but like prudent men they pass the difference between 7 per cent. and 12 per cent. to the reserve. Now, gentlemen, in these days of telegraphic progress (because, after all, telegraphy has, perhaps, revolutionised the world both politically, socially, and commercially to a greater degree than we have realised; and I know that statesmen, leading statesmen, have not yet realised the importance of telegraphy; it takes a long time to realise it), this system has been carried on with quiet but dogged perseverance, and there has been nothing to stop it. There have been no obstacles that have not been overcome, and the result is now that I believe telegraphy has brought the world more together, into a more homogeneous mass, than people have any idea of. And let me say that the object of telegraphy is this—to establish among the nations of the world peace and goodwill. That is the mission of telegraphy; and I believe it will have greater influence in accomplishing that end than anything that has been produced in the present century. Just let me say one word more. We look upon the great progress in telegraphy, but we measure that progress in telegraphy just as an evidence of the progress of trade. There is no transaction of any importance that takes place with China, New Zealand, Australia, Japan, India—in fact, there is no important commercial transaction that does not involve a telegram. It shows you what an influence telegraphy is having upon the world—and where would the world stand at the present moment if telegraphy were to cease [hear, hear]. Mr. Evelyn Ashley very properly said just now that the telegraph broke the other day the connection between this country and South Africa at a critical time. It was unfortunate: and in a very short period I know the anxiety which arose in the particular office over which the hon. gentleman presides. I am sorry to say that this morning it again broke down, but I am equally confident from my long experience of telegraphy that within two days it will be restored. I may tell you that when telegraphy, and submarine telegraphy particularly, was first established, there was an idea that a cable once laid in the bottom of the sea could not be recovered. That is not so. We are now as capable of repairing submarine cables at the bottom of the sea as we are of repairing a railway when an accident occurs. It is exercising an influence which we, who know something of that influence, hope to see have its effect upon those great men who lead the world and cause them to acknowledge that it is one of those elements by which they have been able to direct and guide the affairs of this country in a satisfactory way. Gentlemen, in speaking of America, in speaking of my friend, Dr. Green, I have to say that they have got a magnificent system there. We have connected that system with this country; and when I think of the pleasant two months that I spent last autumn, when I saw that country which has yet unoccupied thousands and tens of thousands of acres—when I think of the thousands and tens of thousands that are pouring into that country year after year, I have no hesitation in my mind as to what the future of America is to be, and of the benefits which that telegraphic system must confer upon the American community, and of the progress which must come from those people who go there in tens of thousands, because they will not only become producers, but they must become consumers as well; and the telegraph, as I have said, being an important element in every transaction, whether political, commercial, or social, that the progress that is likely to attend the telegraphic systems in America, as well as all over the world, is almost beyond what we can foresee or prophecy [hear, hear], and, therefore, gentlemen, I beg to ask you to drink the health of Dr. Norvin Green, who presides over that institution which is benefiting America so largely. He is administering it with great wisdom and great ability, and I only hope that he may be long spared to fill the position which he now occupies so wisely and so well [cheers].

The toast having been cordially received.

Dr. NORVIN GREEN rose to respond amidst renewed cheering. He said: Gentlemen, the only feeling that I have is an overwhelming sense of the distinguished honours you have paid to me. After several days of rocking on the ocean, which was not very agreeable, I received a welcome to the old country from my friend, Mr. Pender. I found the old country, indeed, an old but not a finished one. You are a progressive people. Old as you are, you are making advances and new improvements day by day; I find that some things are growing faster than even in our own country. One of the things that I have heard about London was that it was the place above all others where one lost his individuality and had all the conceit taken out of him. I presume the exception only proves the rule, and I find myself more conceited than ever I was before. Looking out here on the change of scene, viewing the old river which has become classic, seeing the shifting scenes, like a panorama, so different from what we have in the western world, I have been trying to ignore the embarrassing position that I occupy as the particular guest of the directors of the European cables; and it is not particularly comfortable to a modest man, and a plain business man not accustomed to such things. I look across the table and against the window, and I see the word "Welcome." This comes from the representatives of the telegraphy of the three leading nations of the earth, foremost in literature, arts, and sciences, and especially in the front van of civil and religious liberty. I find there intertwined and lapping each other the European and American cables—I find them working together in harmonious action for the common good and the common profit. I conclude, therefore, that there is not so much individuality in this country; but I am more fortunate than deserving because I happen to represent the large institution of which my friend has so kindly spoken. I am lucky, indeed, to be the representative of this division of our growing institutions. It is true I have long looked forward to, and hoped to visit the country of my ancestors, and always in contradistinction to our German friends who speak of the Fatherland I have had a thrilling sensation when any one spoke of the mother country [cheers]. This is the mother country—it is our mother country. In every State of the Union except one, where they have their code acquired from the French system, your common law is the controlling and governing law, unless modified by special statutes. The Law Courts have the same practice as our courts. Your Bill of Rights and your statutes as to personal liberties and personal properties govern our courts of jurisprudence. Some of our legislators, when they can, occasionally attempt to improve upon these institutions [laughter]. Whether these improvements are effected or not it is not for me to say. I have only to say to you that I am totally unequal to find language to express my sense of the distinguished honour which you have done me, and I must return you my sincere thanks for this mark of your approbation. As to the interest which I represent, some of its progress has been depicted by my friend, Mr. Pender. Some gentleman spoke of the length of time which it took the sun to rise on the British dominion—and I believe that it never sets on it; but it takes nearly nine hours for the sun to rise on our telegraph system [laughter]. It has been accomplished by publishing in Shanghai the quotations at the close of business at 3 o'clock in New York. We claim to be doing the best telegraph service that is being done anywhere. You are doing a good service here. I have had some city correspondence which I would not undertake to beat in our city. A gentleman in our office sends me an occasional telegram, and I must say,

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that your service in this country is good. But we have connected the wires of the Chicago Board of Trade with the Produce Exchange, a corresponding organisation in New York, and it is an every day practice for a man to step to the counter of our telegraph office and to send his telegram to Chicago, some 1,050 miles, and to receive an answer before he leaves the counter [hear, hear]. Now, whatever you may say as to telegraph competition, I hold that time is our great competitor; and just as we can overcome time we can increase our business. The business between New York and London would be doubled, perhaps quadrupled, if you could get an answer within an hour. The business between New York and Chicago has been doubled and trebled by the improved service; and just as you can overcome time you can improve the telegraph business [hear, hear], so that I was very favourably struck by the project suggested by my friend, the chairman, of establishing in London an evening exchange, with hours corresponding to the morning hours of our exchange in New York, for the purpose of dealing in American securities, and where the two exchanges could meet each other to receive answers while standing at the counter at Chicago. I have not the slightest doubt that it will be done. There will in consequence be an immense increase of the telegraphic business; and not only so, but it will result in the postal arrangements between the two countries being much improved, and in strengthening the bonds of commerce, which no disputes among politicians can sever. Gentlemen, I am not a speech maker. I desire, in conclusion, to advert to the great stride in modern progress which is annihilating time and space, and which is establishing closer relations between all counties and this great centre of trade and commerce of the whole civilised world. That stride was the spanning of the Atlantic with a telegraph cable, the greatest work of modern times; and there was a feature in that that always impressed me as a part of the progress of the age, that when the first cable was laid, and when in 1866 they effected the successful landing, they went out on the trackless ocean, and, according to the date of the log of the ship, by the advance of nautical science, they picked the cable up, spliced it, and laid it down again. But even after they had laid the cable they had to invent the way to work it. None of the systems known to telegraphy at that time could approach it with any degree of success or satisfaction. We got what we call electrical impulses, and that was all. But then came the cable instrument, which enabled us to work ocean cables with almost the same facility as a land line, but not quite so rapidly; so that the ingenuity of our electrical corps seems to have been equal to the immediate wants. In the progress of electrical science they soon learnt to measure the exact distance at which the current was lost, and they could locate it within a few yards, and send the ship to pick up and splice the cable. These are wonderful achievements in this modern age, and they all result from the necessity of working the Atlantic cable. That cable was a great work, and did more to annihilate time and space, to facilitate commercial transactions, and to bind the political interests of different countries together than any step of progress that has been made in modern times. In the war of 1812 the battle of New Orleans was fought, and there were some 700 or 800 men killed, including General Pakenham, whose body was pickled and brought back home. Well, that battle was fought 15 days after the peace of Ghent, If we had then had the telegraph system no such battle would have been fought, and Andrew Jackson, the victorious General, would never have been made President of the United States. I give you "The Atlantic Cable Companies," coupled with the name of Mr. John Pender, M.P., for it was his pluck and faith in the undertaking which induced him to lend his money, thus saving an enterprise which would otherwise have been given up.

The toast was very cordially received.

Mr. PENDER, M.P., in reply, said: Dr. Norvin Green has associated my name with the Atlantic telegraph enterprise. My friends of the Anglo-American Company and the French and New York Companies have been kind enough to put me in the front place this evening to reply for the United Companies. The company which I represent has only one cable; the Anglo-American Company has four cables. Our French friends and our other excellent friends have only one cable; and the American Company has but two cables. Gentlemen, I have been a man of peace all my life. I found all those companies at one time competing. I thought that the true policy, not only for the world who would enjoy this telegraph system, but for the companies themselves, was that there should be unity of action and harmony between them. I think I may claim the credit of taking a prominent part in bringing about that harmony which prevails at present [cheers]; and, in bringing about that harmony, I am quite sure that I did not injure those great and public interests which ought always to be considered wherever any combination takes place. I believe at the present moment that you have got a very much better telegraphic system than you possibly could have had if those four or five companies had been all competing and destroying one another. But I have another claim to reply to the toast of the Atlantic Telegraph Cables, and that is that I believe I was one of the very few—I think that Sir George Elliot was amongst us—when Mr. Cyrus Field came over from America with an idea that it was possible to span the Atlantic by a wire to take the matter up. I found some men shaking their heads and saying, "Oh! that is an impossibility." One of the great statesmen of the present day told me at a little party that I had gathered together—and I rather think my friend Sir George Elliot was present at that party—that he had never met at a table twelve men who, in their individual capacity, were men of such great shrewdness, great sense, and great engineering capacity. If I were to name those gentlemen, some of you would be perfectly astonished. Many of them are living to-day and are occupying the highest positions, and they were all in earnest, I believe, in the undertaking; but this great statesman replied to me, when I asked him to associate his name with what I believed would be a wonderful success, and would be one of the great bonds of progress in the century in which we live, "I have met many clever men; but never met so many men who were so mad on one point" [laughter]. The idea of laying a line at the bottom of the sea, and expecting to get money out of it, seemed to him to be a most impracticable thing. Now some few years have elapsed since this thing was first commenced, and what has been the result? Instead of one cable, we have got eight cables; but let me refer just for one moment to Mr. Cyrus Field. That gentleman will always be associated with the Atlantic cable; but there was another man—a good old man and a great philanthropist, who made his mark in America perhaps more than any man could possibly do in his life time. I speak of old Mr. Peter Cooper, who died the other day. He was the man who took Cyrus Field by the hand and gave him the money to carry out the idea which was carried out so successfully, and which has now so much influence on the world. I say that this idea, and I am proud to say it, sprang from America. We took it up manfully and willingly here, and it has been a success, perhaps beyond what was ever anticipated for an element which has done more for our progress than anything else in the present century. Let me give the figures—and then I have done—as to the submarine cables. In 15 years we have put £32,000,000 of money into the bottom of the sea; the mileage is 82,000 miles, and the revenue about £3,300,000. All this, as I say, has been accomplished in a very short space of time. I refer to the advantage which this telegraph system has been to commerce. Commerce is the root of all progress. Our first cable cost £5,000,000, and unless that had been a marked success, and unless commerce had demanded it, we would not have had eight cables at present. In fact ten cables have been laid, and eight cables are now living at the present moment in perfect harmony. We are to-day a united company. I believe we are doing great service to the world. We have met here to do honour to our worthy colleague, who has come over to visit us [cheers]. I have to thank you for the honour you have done me.

M. POUYER QUERTIER, who was received with loud cheers, and who spoke in French, then gave "The Progress of Telegraphy throughout the World, coupled with the name of Sir George Elliot, M.P."

Sir GEORGE ELLIOT, M.P.: I have to thank you very much indeed for the handsome way in which you have received my name in connection with the extension of telegraphs over the world. At this late hour I do not intend to occupy much of your time. At the same time I cannot help feeling proud at having my name associated with the toast given in the French language, and in connection with a subject which has always been so very interesting to me. It is quite true that I do not feel any degree of modesty in letting it be known that from the very earliest time I have been connected with submarine telegraphy. I see the place beyond me (the Telegraph and Maintenance Company's works) where most of those cables have been manufactured. Some thirty-one years ago I had a most excellent partner. At that time he did not believe in submarine telegraphy, and simply as a partner I insisted upon having it done in a humble place called Sunderland, in the north of England, and the machinery is still there, where I made the first cable that was ever made, not with partnership money, but with my own. We made some of the largest telegraph cables, and the last one we made was from Malta to Alexandria. Now, I will tell you a little incident, which may strike you as having a bearing upon our meeting to-night. About twenty-five years ago I had obtained a concession from the Austrian Government from Ragusa to Alexandria. I had the concession for this cable, and it was necessary to have the co-operation of the English Government from Crete to Alexandria. I went as a deputation to wait upon our present Prime Minister, Mr. Gladstone, at his own house. I was urging upon the Prime Minister that England ought to have this thing completed as a route to Austria, and that there ought to be some arrangement come to. I recollect very well the remark made by that statesman. Just let me say that I have a very great admiration for Mr. Gladstone, although I do not always vote with him, but the right hon. gentleman said to me: "We have far too many telegraphs, we do not want to be disturbed both night and day."

After the CHAIRMAN had proposed "Our Guests," and Mr. PULESTON, M.P., replied, the company broke up, and returned to town by special train.

THE INDO-EUROPEAN TELEGRAPH COMPANY (LIMITED).

The sixteenth ordinary general meeting of the members of this Company was held at the City Terminus Hotel, Cannon-street, on Monday, the 30th ult.

The MANAGING DIRECTOR (Mr. W. Andrews) having read the notice convening the meeting, the seal was affixed to the register of shareholders, and the report of the directors was taken as read. It stated, *inter alia*, that there was a balance of £28,787 to be dealt with, "and the directors propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 15s. per share, both free of income-tax, making in all 9 per cent. for the year. The balance of £1,162 will be carried to the credit of 1883. The Company has leased from the Post Office a special wire from its central office in London to Manchester and Liverpool, in which places offices of the Company were established and opened in the autumn of 1882. The maintenance by the Company of its own lines is working satisfactorily."

The CHAIRMAN said: Gentlemen, the report is a little longer than usual, but I am happy to say that that is not, as long reports usually are, an indication of coming disaster. I have generally observed that long reports are usually intended to explain deficits. In our case there is something very much more satisfactory. We made £118,000 in the past year, against £101,000, in round figures, in the previous year. That considerable increase of revenue was due, as we state in the report, entirely to the war in Egypt. During that war the wires of our friends, the Eastern Company, were totally cut down and destroyed for some months, and it therefore fell on us to conduct the entire telegraphic communication between England and India, trans-India, including China, and the Cape of Good Hope and Southern Africa—a province lying entirely out of our ordinary beat—and, strange to say, the urgencies of the case were such that a great many communications for Egypt itself were transmitted by us through India—*viâ* India to Egypt. That was a singular instance of the great value of telegraphic communication. I am happy to state that that work, the whole telegraphic business of the country, was carried out without hitch or break, or any slackness or difficulty. The extra work done was actually more than double that which we had done in the year before, although we have not derived the entire profit of all that extra work, consequent on our joint-purse arrangement with the Eastern Company—an arrangement which has proved very beneficial for them, as it has also proved very beneficial to us in past times, and may do so again. But this enormous increase of work—as I have stated, more than double—was done

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with an increase of less than 1½ per cent. in the total amount paid for salaries and wages in the preceding year. That is a strong and an additional instance of the value of telegraphic communication, showing how much may be done when once the plant and establishment are there, and provided also that both the plant and establishment are good of their kind and well managed; and I may say, without exulting too much on the part of the directors, that the business was very well managed. I say that because the chief person who has established that excellent management, who saw to our plant, who trained our staff so that when the time and need came we should be able to work efficiently, was my friend Mr. Andrews. In alluding to the dividend we are now about to propose to you, I might say that, although it is a very reasonably handsome dividend, the fact is that up to the present time, if you take the average of dividends we have declared since the first establishment of our Company, you will find that they have been under 4 per cent., so that in point of fact, though 9 per cent. is a very good thing, the average outcome of the affair up to the present time is not as much as we trust in a few years we shall be able to show it can do and has done. Among other items we allude to in the report we state that we have purchased a large quantity of stores and plant from the Messrs. Siemens. It is a sort of difficult operation to purchase stores and see that they are all of the proper kind when they are spread over such enormous distances as was the case in this instance—lines extending through Germany and Russia and very many hundred miles. This work was simplified by the excellent arrangements made by Messrs. Siemens, who, of their own accord, set aside all obsolete and decaying material, and handed over such good working stuff as we were only too glad to take, for you must all be well aware that a large amount of spare stores is absolutely necessary to continue the work of the Company's line of telegraphs. We have taken over this enormous amount of stores without let or hindrance; without any litigious spirit, and leaving, I hope and believe, good feeling between both parties. A matter of satisfaction I have to mention is the renewal of the Persian concession for ten years. Some difficulty was apprehended about that. It has taken considerable time to bring about, but it has at last been conceded, and on favourable terms, so our concession runs now with all the different countries connected with the line for the full period of thirty-five years. I see no particular reason why at the end of that time it may not be renewed still further. We now come to a matter which I know has puzzled a great number of the shareholders—that which is called the Persian debt. You find it referred to at the foot of the accounts under the head suspense account. The difficulty connected with this matter is in reality very small, if you will only take the trouble to go into it. I will endeavour to give you an idea of what the Persian debt is. The line through Persia, which necessarily connects our line through Germany, Russia, and the East, was constructed for the Persian Government by the Indian Government, and the cost, £47,000 odd, was, after many arrangements between the three parties—the Persian Government, the Indian Government, and ourselves—finally arranged to be paid by Persia to India in the following manner:—First, we agreed to pay a portion of the tribute, or royalty, due from us to Persia, instead of paying it to Persia to pay it annually to the Indian Government. That is, or when the last is paid will amount to, about £23,000 out of the £47,000. It was a matter of no concern to us whether we paid it to the Persian or the Indian Government—the money would have to be paid, anyhow. The balance of this amount, however, we agreed should be deducted from our profit of the line, and paid over to the Indian Government, and the Persian Government on their behalf stated that when this was paid off we might go on deducting the amount year by year from the tribute payable to them till we had recouped ourselves. In the year 1874 we had paid a large amount out of our profits, £9,000. We were then, unfortunately, in a very sad state of impecuniosity. We found it very difficult indeed to keep up these payments, and the Indian Government very obligingly deferred exacting the remaining sum from us till we were in better circumstances. Last year they claimed performance of the agreement, and we handed over to them the amount of profit made on the Persian line, and which you find here in the return, amounting to £6,416. There still remains a sum of about £5,700 payable, which, no doubt, will be paid out of the profits of the present year, and with that payment our payments will come to an end, and thereafter, for the next eleven years, we shall recoup ourselves by the payment of nearly £2,000 a year until the whole of our advances on behalf of Persia have been paid off. We shall thus commence, from the year 1884, to be actually in receipt of nearly £2,000 a year for eleven years more than we have hitherto been receiving. We therefore thought that that was payment in the nature of reserve. I am afraid I have not made myself thoroughly intelligible to some, but if any gentleman here is such a glutton for figures that he is very desirous to see the minutiæ of this statement, if he will only apply to our excellent, efficient, and courteous accountant I am quite sure he will receive from that gentleman sufficient to satisfy the most rabid appetite for figures, and to explain up to the last farthing how this complicated account has been made out. Among other matters we have to refer to the cable conference at Paris. When I addressed you last year I had to speak in somewhat despondent tones of the delay and damage we had met owing to the injuries inflicted on submarine cables. The Government at last, after some pressure, took up the subject, and on communicating with foreign Governments a conference was held at Paris, and sundry agreements were there come to which we trust will be fully carried out, and which we hope will put an end substantially to all the various causes of complaint. I have only further to mention that you will see that in one way or another we carry rather more than usual to our reserve fund this year. We have £5,000 of actual cash payment, as it were, but we have other sums in the nature of a reserve. There are the stores and freehold buildings taken over from Messrs. Siemens. Instead of spreading their payment over a period of years, we thought it desirable in your interests that it should be paid off at once. It is part of the policy we have always adopted, since we have had the means of doing it, of paying the cost of everything that has occurred in the year, so as to leave a free and clear balance-sheet. I think you will admit that the value of our property in the market at the present day justifies the course we have hitherto taken with your sanction, and which we now hope to follow in this particular course with your sanction. The shares now stand at a very high figure because we have paid sums as they have fallen due, and because we have instituted a reserve fund, which I hope and trust yet to raise to a very much higher figure. I have no further remarks to make except to reply to any question which any shareholder may ask. I now move "That the report and statement of accounts be received and adopted."

Mr. H. WEAVER seconded the motion, which was carried unanimously.

The CHAIRMAN next moved the payment of the dividend and bonus recommended.

Mr. J. HERBERT TRITTON seconded the motion, and it was carried unanimously.

On the motion of the CHAIRMAN, seconded by Mr. C. W. EARLE, Major General G. B. Tremenhere, R.E., and Mr. Tritton, the retiring directors, were re-elected, as were also the auditors, Messrs. C. F. Kemp, Ford, and Co.

Major WOOD then moved a vote of thanks to the chairman and directors, and observed that it must have been most gratifying to the shareholders to have heard such a statement of their affairs as had been placed before them.

Mr. WILLIAM PAYTON seconded the motion, and it was carried unanimously.

The CHAIRMAN having briefly acknowledged the vote, the proceedings terminated.

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES MAY 5.		BUSINESS DONE WEEK ENDING MAY 5. Highest.	Lowest.
Anglo American	51,	52	51½	51½
Do. Preferred	83½,	84½	84	83½
Do. Deferred	20½,	21½	21 3-16	20½
Brazil Submarine	12¾,	12¾	12 11-16	12 9-16
Cuba	10,	10½	—	—
Do. Preference	17,	18	17¾	17¾
Direct Spanish	5½,	5¾	5 11-16	5¾
Do. Preference	16,	16½	—	—
Direct United States Cable	12¾,	13	13 1-16	13 1-16
Eastern Telegraph	10⅞,	11	11¼	10⅞
Do. 6 per Cent. Preference	13¼,	13⅝	13⅝	13 7-16
Do. 5 per Cent. Debentures, 1899	104,	107	105½	105½
Eastern Extension	12,	12¼	12 7-16	12¼
German Union	10,	10½	—	—
Globe Telegraph and Trust Company.	7½,	7¾	7¾	7 3-16
Do. Preference	12½,	13¼	13 3-16	12 15-16
Great Northern	13¼,	13⅝	13⅝	13¼
Indo-European	33,	34	33½	33½
Mediterranean Extension	1⅝,	2¼	—	—
Do. Preference	6,	7	—	—
Reuter's	9½,	10	—	—
Submarine	247,	252	250	250
West India and Panama	1½,	1½	—	—
Do. 1st Preference	7¾,	8½	7¾	7¾
Western Brazilian	7½,	7¾	7¾	7¾
West. Union 7 per Cent. 1st Mortgage	125,	123	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	¾,	1	¾	13-16
Oriental	¼,	½	—	—
United Telephone	10,	10½	10 5-16	10 5-16

ELECTRIC LIGHT.

Anglo-American Brush Light (£7 pd.)	5,	5½	5½	5
Do. (fully paid)	7,	8	—	—
Hammond Light	2¾,	3¼	3¼	2¾
Eastern Electric (fully paid)	—,	—	—	—
Pilsen, Joel, and General Electric	⅛,	¼	—	—
Swan	1¼,	2¼	1 15-16	1 15-16
Maxim-Weston	⅛,	¼	¼	¼

TRAFFIC RECEIPTS FOR APRIL, 1883.

COMPANIES.	April, 1883.	April, 1882.	Increase.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,900	3,921	—	21
Direct Spanish Telegraph Company	1,766	1,824	—	58
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	—	—	—	—
Eastern Extension Telegraph Company	—	—	—	—
Great Northern Telegraph Company	—	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

DIRECT SPANISH TELEGRAPH COMPANY.—The estimated traffic receipts of this company for the month of April, 1883, were £1,766, against £1,824 in the corresponding period of last year.

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THE NEW MATERIAL

or ENGINEERS (Sanitary and Hydraulic), ELECTRICIANS, AXLE MAKERS, BRASSFOUNDERS, PUMP MAKERS, RAILWAY COMPANIES, CARRIAGE and WAGGON BUILDERS, &c.

SUBSTITUTE FOR LEATHER, RUBBER, AND PERCHA.

It is unequalled for Washers of all kinds, Hot and Cold Water Packings and Plumbers' uses generally, Insulators, &c.

THE PATENT VULCANISED FIBRE

Is supplied in Sheets from 1-32in. to 1in. in thickness, and in two qualities: Flexible, 2s. per lb.; Hard, 2s. 3d. per lb.

MOSSES & MITCHELL, 68, 69, 70 & 71, CHISWELL ST., LONDON, E.C.

IMPORTANT TO TELEGRAPH COMPANIES.

SOAPS AND DISINFECTANTS

For Use at Home and Foreign Stations.

"THE MANAGING DIRECTOR, THE SANITAS COMPANY (LIMITED). "February 4th, 1880.
"We have now for more than a year been using your SANITAS soap and disinfectants in our ships, as well as at our stations, and find it greatly appreciated, more especially at tropical places."

"London, 15th November, 1880.
"I think it right to inform you that our Superintendent at Mozambique says:—'I use the much-prized "SANITAS" freely, and feel perfectly safe wherever I sprinkle it.' "JAMES ANDERSON, Managing Director, Eastern Telegraph Company (Limited), 65, Old Broad-street, E.C."

SANITAS DISINFECTING FLUID, POWDER and SOAPS.

SANITAS Fluid is Colourless, Fragrant, Non-Poisonous, and gives no stain.

THE SANITAS DISINFECTANTS ARE USED BY 600 PUBLIC HEALTH BODIES.

Samples and Prices on application to the SANITAS COMPANY, Limited, BETHNAL GREEN, E.

IN the HIGH COURT of JUSTICE, CHANCERY DIVISION.

IN the MATTER of THE COMPANIES' ACTS, 1862 and 1867, and IN the MATTER of the PHŒNIX ELECTRIC LIGHT and POWER COMPANY (Limited).

The Creditors of the above-named Company are required on or before the 10th day of May, 1883, to send their names and addresses, and the particulars of their debts or claims, and the names and addresses of their solicitors (if any) to HENRY BISHOP, of 41, Coleman-street, in the City of London, the liquidator of the said Company, and if so required by notice in writing from the said liquidator, are by their solicitors to come in and prove their said debts or claims at the chambers of Mr. Justice Pearson, at the Royal Courts of Justice, Strand, in the county of Middlesex, at such time as shall be specified in such notice, or in default thereof they will be excluded from the benefit of any distribution made before such debts are proved.

Wednesday, the 23rd May, 1883, at 12 o'clock at noon, at the said chambers, is appointed for hearing and adjudicating upon the debts and claims.

Dated this 11th day of April, 1883. E. W. WALKER, Chief Clerk.

Freshfields and Williams, 5, Bank-buildings, London, E.C., Solicitors for the Liquidator.

JOURNAL of the SOCIETY of TELEGRAPH ENGINEERS and of ELECTRICIANS.

Edited by Professor AYRTON, F.R.S.

No. 47 contains Illustrated Articles on:—
"THE MEASUREMENT of ELECTRICITY for COMMERCIAL PURPOSES," by J. SHOOLBRED.
"NEW TELEPHONE TRANSMITTERS," by J. MUNRO.
Together with original communications and abstracts from foreign periodicals.
Price Three Shillings.
E. and F. N. SPON, 16, Charing Cross.

FAURE-SELLON-VOLCKMAR ACCUMULATORS.

On and after 1st January, 1883,
THE
ELECTRICAL POWER STORAGE COMPANY
(Limited),
4, Great Winchester-street Buildings, E.C.,
will be prepared to supply
FAURE-SELLON-VOLCKMAR ACCUMULATORS.
Which can be used in conjunction with any Incandescent Lamp or Electrical system, and afford the only reliable and economical means of Lighting Private Houses, Hotels, Theatres, Ships, Railway Carriages, &c., by Electricity.
Particulars and prices post free on application.

DYNAMO for SALE, lights six 20 c.-p. lamps, or one arc of 250 c.-p. £8. Plating dynamo, £10. Other sizes and parts and castings equally cheap.
OPPERMANN BROS, 172, St. John-street, E.C.

FACTORY and WATERSIDE PREMISES to be LET, or the LEASE, at £200 per annum rent, to be SOLD. First class premises, with a frontage of about 40ft. to the canal, and 40ft. on the other side to the road. Depth about 90ft., ground floor of factory, with two floors above, 18ft. by 8ft. Steam power on the premises, to be taken at a valuation. Situate close to King's Cross. Apply to the SECRETARY of the London General Cab Company, 68, York-road, King's Cross, N.

CARBONS.—For all kinds of ELECTRIC LIGHT, Leclanché, Bunsen, and Grenet Batteries, Telephones, &c.
The best, cheapest, and most reliable for every kind of Lamp.
Carbons of any size, shape, and of every description manufactured to order at the shortest notice.
JAMES W. COLUMBINE,
2, Carlisle-street, Soho-square, W.

H. NEWBOLD,
Experimental Glassblower,
25, CALTHORPE STREET, W.C.
Mercurial Exhaust Pump & Vacuum Tube Maker.
INCANDESCENT LAMPS, &c.
STRICT ATTENTION PAID TO DRAWINGS AND DESIGNS.

SOMETHING QUITE NEW.
THE INSULITE ELECTRIC BATTERY AND BELL.
PATENTED AND REGISTERED.
Ready for use, sealed, portable, lasting, clean, convenient, and safe.
For HOUSE BELLS, ALARMS, SHOP CALLS, SICK ROOMS.
PRICE 25s. Carriage paid to any Railway Station.
May be had from Ironmongers, Gas Fitters, and Instrument Makers, &c.
The BRITISH INSULITE CO., Limited,
20, COLEMAN STREET, LONDON, E.C.

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SLIP

CAPE COLONY.—News from South Africa says that the telegraph line was opened to Tarkastad on April 7.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.—The traffic receipts of this company for the week ended May 4 were £3,039.

H.M.S. "HIMALAYA."—The Swan Company have heard by telegraph that their installation upon H.M.S. "Himalaya" worked without any hitch during her outward voyage.

EASTERN TELEGRAPH COMPANY.—The traffic receipts of this company for the month of April, 1883, amounted to £45,148, and to £42,667 in the corresponding period of 1882.

THE TELEPHONE IN NOTTINGHAM.—We are informed that the messages passing through the National Telephone Company's Exchange at Nottingham now exceed 1,000 per day.

BURNING OF A DYNAMO SHED.—An American paper says:—"The building containing the generating apparatus of the Brush Company, at Cincinnati, was burned on the 21st instant."

THE PATENTS BILL.—Owing to representations which have been made to the Government, it is understood that an earnest endeavour will be made to deal with the Patents Bill during the present Session.

THE UNITED TELEPHONE COMPANY.—Between the 1st of January and the 1st of May this year the United Telephone Company have added 390 new names to the list of subscribers to their metropolitan exchange.

MR. FAWCETT.—*The Times* Paris correspondent says that Mr. Fawcett is likely, on Saturday (to-day), to succeed the late Mr. Newmarch as Corresponding Member of the Academy of Moral and Political Sciences.

THE LUMLEY COURT AT THE AQUARIUM.—On the occasion of the National Liberal Club banquet, held at the Westminster Aquarium the other day, Mr. Gladstone utilised the Lumley Court as his reception room.

EASTERN EXTENSION TELEGRAPH COMPANY.—The traffic receipts of this company for the month of April, 1883, amounted to £32,005, and to £29,269 for the corresponding period of 1882, being an increase of £2,736.

ROYAL SOCIETY.—At this society's meeting on Thursday last, Professor Hughes was to read a paper on a "Theory of Magnetism based upon New Experimental Researches," in continuation of a previous paper on the same subject.

DEVON AND CORNWALL ELECTRIC LIGHT COMPANY.—Mr. Justice Chitty has fixed the 18th of May, at his chambers, in the Royal Courts of Justice, Strand, as the time and place for the appointment of an official liquidator for this company.

CORK INDUSTRIAL EXHIBITION.—The tender of Messrs. Emerson, Murgatroyd, and Co. for lighting the Cork Exhibition building with incandescent lamps has been accepted. The Earl of Bandon has consented to open the exhibition on the 3rd July.

IRISH CABLES.—The *Daily Telegraph* of last Wednesday says:—"It is stated that one of the telegraph cables between England and Ireland is to be immediately taken up for repairs, and that a great delay in the transmission of messages is consequently anticipated."

THE METEOROLOGICAL SOCIETY.—At the ordinary meeting of this society, to be held on the 16th inst., at seven p.m., the following paper, amongst others, will be read:—"New Method of Reading a Thermometer and a Hygrometer at a Distance by means of Electricity," by Arthur W. Waters, F.G.S., F.Z.S.

THE AMERICAN BRUSH COMPANY.—The works of the Cleveland Brush Electric Company, including their new addition, which is now almost completed, cover six acres of ground. A draft stack which the company have recently put up is capable of making a draft for engines and boilers aggregating 1,500 horse-power.

WEST INDIA AND PANAMA TELEGRAPH COMPANY.—At a meeting of the Board of Directors, held on Wednesday, the accounts to the 31st December last were submitted, and showed a balance of £21,201 4s. 7d. on revenue account. The directors decided, after placing £15,000 to reserve, to carry the balance of £6,201 4s. 7d. forward.

TO BE WOUND UP.—The Anglo-General Electric Light Company, of 4 and 5, Three Crowns-square, Southwark, S.E., and the Anglo-Colonial Electric Light Company, of the same address, are to be wound up voluntarily. Mr. C. F. Reynolds, of 13 and 14, King-street, Cheapside, E.C., has been appointed liquidator in both cases.

LONDON PLATINO BRAZILIAN TELEGRAPH COMPANY.—The revenue of this company for the month of December is estimated at £2,015 (Western Brazilian portion, £1,325; Land Lines, £690), as against £2,106 for the corresponding period of 1881. The directors announce a final dividend of 3s. per share, being at the rate of $2\frac{3}{4}$ per cent. per annum.

THE JABLOCHKOFF SYSTEM.—The Strand Vestry has decided to give the lighting of its parishes, including St. Anne, Soho; St. Paul's, Covent Garden; St. Clement Danes, St. Mary-le-Strand, Liberty of the Rolls, and the precincts of the Savoy, to the Jablochkoff Electric Light and Power Company, under a seven years' license. This company have erected several of their lamps outside the Gaiety Restaurant, in the Strand.

GREAT NORTHERN TELEGRAPH COMPANY.—The traffic receipts of this company in April, 1883, amounted to £20,490. For the period 1st January to 30th April, 1883, they were £76,920, against £72,350 for the corresponding months of 1882, and £71,156 for the same period of 1881. A final dividend of 6s. per share for 1882 is now payable at this company's bankers, Messrs. C. J. Hambro and Son, 70, Old Broad-street, E.C.

THE ZANZIBAR-MOZAMBIQUE CABLE.—An Exchange Telegraph Company's telegram, dated 4:20 p.m., Thursday, says: "The Eastern Telegraph Company announce that the repairing ship 'Great Northern' has now buoyed both ends of the Zanzibar-Mozambique cable, and is seeking for a better bottom in which to relay the cable, which has broken three times in the same locality. The communication is expected to be shortly restored."

LICENSES FOR TELEPHONE LINES.—The chairman of the National Telephone Company writes to a daily paper as follows:—"I have had negotiations with the department in reference to inter-town telephonic communication, and the Postmaster-General has refused to my and to all other private telephone companies the license to erect trunk wires between town and town. He, however, undertakes to do the work himself, and to let the wires to the telephone companies."

TELEGRAPH MATERIALS WANTED.—The Great Eastern Railway Company are inviting tenders for the supply of telegraph materials, india rubber, &c. Forms of tender can be had on application to the secretary's office, Liverpool-street Terminus, E.C. The patterns may be seen at the Stores,

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Stratford, E., between 10 a.m. and 4 p.m., from 16th to 24th inst. inclusive. Persons applying should state the particular contract or contracts for which they propose to tender. Tenders, endorsed "Tender for Stores," must be forwarded to Mr. J. Hadfield, secretary, Liverpool-street Terminus, E.C., by 10 a.m., on the 26th inst.

Electrical Transmission of Power.—We had hoped to have been able to give a *résumé* of a report on some further experiments made with M. Marcel Deprez's machines and installation at the Northern Railway's workshops, Paris, in our present issue. The length of our correspondence and the pressure of other matter for which a place must be found in the last number of this volume has obliged us to defer the publication of this *résumé* until our next issue. We may mention, however, that the further experiments were made by a special committee appointed by the Academy of Sciences, and were carried out on the 4th of March.

Electric Exhibition at Vienna.—We are informed that the French are the first among the exhibitors at Vienna who have completed the plan of their exhibits. The French telegraph department will have a richly-decorated pavilion in the centre of the section devoted to their country, in which some valuable historical apparatus will be shown, as well as modern instruments. With this pavilion as the centre, the French section will occupy an area of 1,500 square metres; this, of course, does not include machines in action, which will be shown in the machine room. Close to France will be found the representatives of Russia, who will occupy from 300 to 400 square metres.

The Telephone in Malta.—The Compagnie Internationale des Téléphones have opened an exchange at 27, Strada Mercanti, Valetta, Malta. It is to be open day and night. The annual subscription is as low as £8 per annum, no matter what distance the subscriber may be from the exchange. The Ader transmitter and receiver are used. The wires are all of silicated phosphor bronze, a substance which is rapidly coming into repute for this class of work on account of its durability and conductivity. Branch offices have also been established at the Bourse, the central police station, Chamber of Advocates, Theatre Royal, railway station, and elsewhere. The management of the exchange has been placed in the hands of Chevalier Edward Rosenbusch, C.E., well known in the island as having been instrumental in introducing many useful novelties.

Electric Lighting in Dublin.—We understand that the new premises recently fitted up for the offices of the *Irish Times* in Westmoreland-street, Dublin, are to be lighted throughout on the incandescent system of electric lighting. The installation is to be erected by Messrs. Siemens, and will consist of 150 Swan lamps of 20 candle-power each, worked by an alternate current machine and an exciter. The lamps will be arranged in four circuits, so that one or more circuits may be cut off at pleasure, and each lamp will be provided with a switch for putting on or off the current as occasion may require. Safety plugs are also to be inserted where necessary. The dynamos will be driven by a 12 horse-power Crossley gas engine, and suitable counter shafting, a fly wheel being provided on the exciter for the purpose of overcoming the usual unsteadiness of this class of engine. The installation will be carried out under the superintendence of Mr. J. Angelo Fahie, Mem. S.T.E. and E., of Dublin.

Electric Lighting for Poplar.—At a recent meeting of the Poplar District Board of Works a report was received from a special committee appointed to consider the Brush Company's provisional order. The committee recommended that two areas in the district should be agreed upon for the operations of the company. The areas were (1) that portion of the district bounded on the west by the Blackwall Extension Railway, on the south by Archibald-street, south of the North London Railway Company's engine house to the angle of High-street, thence along High-street; and for the eastern boundary the River Lea, the specified thoroughfares affected being Bow-road and what was formerly High-street, Bow, between the boundaries named; (2) so much of the district not included in the other area as lies south of the Great Eastern Railway from Old Ford station eastwards. The amount to be appropriated in the first instance to be £7,500, and 5 per cent. of that amount to be deposited in accordance with the terms of the order.

The General Post Office.—In the House of Commons on Monday last, Mr. Ritchie asked the Postmaster-General whether it was proposed to enlarge the accommodation of the telegraph department of the General Post Office by adding a story to the present building; what height from the ground the new story would be; how many persons would be located in the building when completed; and what precautions against fire it was proposed to take? Mr. Fawcett said: "In reply to the hon. member, I may state that the height of the floor of the new story in the telegraph department above the pavement is 76ft. The maximum number of persons employed in the entire building is about 2,500. Of course the whole number are not employed at one time. About 300 are employed at night. The building is fireproof, and every precaution is taken against fire by having large tanks on the top of the building and hydrants on each floor. The means of exit are so good that it is considered that the whole staff at the busiest time in the day could leave the building in ten minutes." In answer to a further question from Mr. Ritchie, Mr. Fawcett stated that to the best of his belief no more than 2,000 persons were ever employed in the building at the same time.

Electric Light on Ships.—The new paddle steamer "Rio Pardo," built and engined by Messrs. Caird and Co., Greenock, for the National Brazilian Steam Navigation Company, to be employed on the coasting trade between Rio de Janeiro and Buenos Ayres, went her official trial on Thursday week (May 3), and proved in every respect a great success. The dimensions of the vessel are as follow:—Length, 272ft.; breadth, 34ft.; and depth from spar deck, 19ft. 8in. The engines are compound oscillating, of a nominal power of 300 horse, working to 1,600 horse, the cylinders being 45 and 80 by 60. Two multitubular double-ended steel boilers with eight furnaces give a full "head" of steam. The vessel has been fitted throughout with electric light by the Edison Electric Light Company, under the supervision of Mr. C. T. Grant, Glasgow, and Mr. Cochrane. The Union Steamship of New Zealand have entrusted the lighting of their new mail steamer the "Takapuna," now finishing at Barrow, to the Edison Electric Light Company. When completed this will form the third vessel of this line which has been lighted on the Edison system, two others being lighted by means of Swan lamps and Siemens dynamos. We are glad to find that the company have such faith in electric lighting.

Telegraph Clerks at Belfast.—In the House of Commons on Monday night Mr. Biggar asked the Postmaster-General if it was true that there were a number of telegraph clerks in the Belfast office, with from nine to twelve years' service, performing night and Sunday duty, who were only allowed two weeks' annual leave, while others in the same office with only six or eight years' service, performing exactly similar duties were granted an annual leave of three

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weeks; if that were so, why was this distinction made between members of the same staff of the Belfast office, and would he have the anomaly removed; and if it was not also a fact that clerks in the Dublin office, with similar service, and performing precisely the same duties, were allowed three weeks' leave in the year. To which Mr. Fawcett answered:—"I stated, in reply to a question put to me last year, that the telegraph clerks at Belfast had been found to be enjoying exceptional indulgence in the matter of annual leave of absence, and this indulgence, while continued to those who already enjoyed it, was not to be extended to others. The officers referred to as having only a fortnight in the course of the year, though of longer service than some who have three weeks, have entered the Belfast office since the difference between that office and others has been discovered. As regards Dublin, I may state that some time since it was decided that future entrants into that office would be allowed only the same period of annual leave as the staff at Belfast."

M. Philippart.—A telegram from Paris, dated Monday night, says:—"The financier Philippart, who has been for several days in the Conciergerie, was this morning sent in custody to Brussels, the French Government having come to the conclusion that a good case for his extradition is established." M. Philippart has also written to the daily papers, enclosing a copy of a letter which he has addressed to the Minister of Justice in Paris. The letter is to the following effect:—"Paris, May 5.—M. le Ministre,—When the Belgian Parquet first asked for my extradition upon an accusation that I had falsified and destroyed the books of the 'Société la Force et la Lumière,' I considered it my duty to resist, for the demand was illegal in form and unjust in principle, the books in question having been placed in the hands of the Belgian Parquet from the commencement of the proceedings. The statement drawn up by my counsel, Maître Clunet, and approved by Maître Senart, proves this conclusively. Evidently my course of action was only too correct, for to-day the Belgian Parquet, in answer to my defence, sees fit to to formulate a charge of forgery against me. This charge is most odious, and will not bear examination for a single instant; but my honour requires that I should be in a position to defend myself, and therefore it is now I who request the French Government to accord my extradition, and with the least possible delay, in order that I may confound my accusers before the Belgian Tribunals.—I beg you to accept, M. le Ministre, the assurance of my highest consideration, (Signed) Simon Philippart."

British Association.—The fifty-third annual meeting of this association is to be held at Southport in September next. The President elect is Professor Arthur Cayley, F.R.S., of Cambridge University. The following is the official programme of the general and evening meetings:—The first general meeting will be held on Wednesday, September 19, at eight p.m., when Sir C. W. Siemens, D.C.L., F.R.S., will resign the chair, and Professor Cayley, F.R.S., President elect, will assume the presidency, and deliver an address. On Thursday evening, September 20, at eight p.m., a *soirée*; on Friday evening, September 21, at 8:30 p.m., a discourse on Recent "Researches on the Distance of the Sun," by Professor R. S. Ball, LL.D., F.R.S., Astronomer Royal for Ireland; on Monday evening, September 24, at 8:30 p.m., a discourse on "Galvani and Animal Electricity," by Professor J. G. McKendrick, M.D., LL.D., F.R.S.E., Professor of Physiology in the University of Glasgow; on Tuesday evening, September 25, at eight p.m., a *soirée*; on Wednesday, September 26, the concluding general meeting will be held at 2:30 p.m. The officers of Section A, Mathematical and Physical Science, are as follow:—President: Professor Henrici, Ph.D., F.R.S. Vice-Presidents: Professor Balfour Stewart, F.R.S., and Professor Stokes, D.C.L. Secretaries: W. M. Hicks, Professor O. J. Lodge, D.Sc.; D. McAlister, D.Sc. (Recorder); Professor Rowe, B.Sc. Those of Section B., Chemical Science, being:—President: J. H. Gladstone, F.R.S. Vice-Presidents: Hugo Müller, F.R.S., and Professor T. E. Thorpe, F.R.S. Secretaries: Professor P. Phillips Bedson, D.Sc., F.C.S. (Recorder); H. B. Dixon, F.C.S.; H. Foster Morley, B.Sc., F.C.S.

Manchester Electric and Gas Exhibition.—The exhibitors held a *conversazione* on Friday last in connection with the Manchester Electric Lighting, Gas Lighting, and Engineering Exhibition, and there was a large attendance of ladies and gentlemen who had been specially invited by the committee. An excellent programme of music and other entertainments was provided, with several novelties on the application of electricity, including the electrical tricycle. Mr. W. E. Heys also delivered a short lecture on electric lighting, popularly explained and illustrated by experiments. The point chiefly dealt with by Mr. Heys was the progress made in the development of accumulators or storage batteries, the construction and principle of which he explained. Without attempting to indicate all the uses to which these storage batteries might be applied for the development of motive power, there was one convenience attending their use to which he said he might specially allude. This was in the fact that, whereas with a dynamo alone they had an unalterable pressure or electromotive force, with the storage battery they could, by division or addition, obtain any pressure that might be desired, and the resulting current would in all cases be absolutely steady and free from those pulsations which they might observe in lamps deriving current direct from a dynamo, especially where the dynamo was driven by an unbalanced gas engine. He also wished to remove what he found was a popular impression, that the accumulators had to be removed from the place of their use to a central station or elsewhere for charging. This, save in exceptional cases, was not the case; the storage batteries were just as much a a part of the permanent installation as the dynamo itself, as they might be charged or discharged through any reasonable length of conductor.

Chelsea Vestry and Electric Lighting.—At the last meeting of the Chelsea Vestry a report was received from the Electric Lighting Committee to the effect.—1. That they have received from the Board of Trade printed circular letters, dated April 13, and orders therewith, in respect of the Chelsea electric lighting, the South Kensington district electric lighting, and the Victoria district electric lighting, from which it appears that the Board of Trade have so far modified their views that whereas they formerly suggested that the amount of capital to be deposited or secured should be one half the amount required to execute the works, they now require that such amount should "not exceed" one half. The committee consider that it will be gratifying to the vestry to learn that the Chelsea electric lighting order, being the first completed one, has been adopted by the Board of Trade as the basis for orders generally, and has been sent by that Board to such local authorities and electric lighting companies as are concerned in similar applications. 2. Submitting that they have received from their chairman a report from which they learn that the Metropolitan Brush Electric Light and Power Company have proposed to reduce the number of streets in Schedule A to be compulsorily lighted within the two years, by omitting Hans-place and the portion of Pont-street west of Sloane-street, and by so doing to diminish the amount of

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capital to be set aside from £30,000 to £20,000; and have further proposed that the sum to be deposited or secured shall not exceed £10 per cent. thereon, and reporting that in consequence of the Board of Trade requiring a reply before the 23rd instant, they have, on behalf of the vestry, agreed to such proposals, and have notified the Board of Trade accordingly. On the motion of Mr. Mossop (chairman of the committee) the report was unanimously adopted, and he and the surveyor (Mr. G. H. Stayton, C.E.), were authorised to settle the remaining details of the order.

Australasian Electric Light Company.—A circular has been sent to the shareholders in this company giving some account of Sir Julius Vogel's visit to Australia and New Zealand on behalf of the company. We make the following extracts:—"It is evident now, from Sir Julius Vogel's reports, that considerable time was lost to the company from several causes, foremost among them being the fact that the predilection of the public in the colonies was, in the first instance, more in favour of incandescent than arc lighting, while the plant at the command of the company was at first exclusively arc plant. An important sale, however, of the latter has been made to the Victorian Government, together with a couple of incandescent machines, consequent upon the great success of the lighting of the Spencer-street Railway Station in Melbourne, the terminus of the greater part of the extensive railway lines of that colony. In Sydney, too, the Government are in the same way likely to take over an extensive installation at the Circular Quay, and in New Zealand the local company has secured the Lyttelton Harbour against all competitors. Other sales of arc plant have taken place, but the chief demand for internal lighting is undoubtedly for the incandescent system. In this Sir Julius Vogel reports there is practically an unlimited field, and there can be now absolutely no doubt as to electricity being the cheaper and better illuminant for these climates. It is also the directors' view that a very large field is opening for profitable business in the colonies, the cost of the incandescent light being estimated, on sound authority, at very much less than that of gas in any of the colonies, and the great heat of the climate giving a further immense advantage to electricity. A fair amount of incandescent plant has now reached the company's agents, after many disappointments on the part of manufacturers. Victoria and New South Wales have been reserved for the development of business by the company itself, while in New Zealand, South Australia, Tasmania, and Queensland, the formation of local companies is being carried out with, it is believed, every prospect of success."

Underground Wires in New York.—From the *New York World* we learn that a meeting of the General Committee on Underground Electrical Communication was held on Wednesday, April 25th, in that city. The committee consists of Governor Cleveland, Mayor Edson, and the following gentlemen:—H. L. Bailey, Time Telegraph Company; D. H. Bates, Western Union Telegraph Company; A. B. Chandler, Fuller Electrical Company; W. A. Childs, Law Telegraph Company; H. Cummins, Postal Telegraph Company; L. E. Curtis, United States Electric Light Company; J. P. Davis, Metropolitan Telephone and Telegraph Company; S. S. Eaton, Edison Electric Light Company; C. R. Flint, Western Electric Light Company; R. R. Hazard, Gramme Electrical Company; E. Holmes, Holmes's Burglar Alarm Telegraph Company; C. D. Hotchkiss, Mutual District Messenger Company; W. M. Ivins, Jablochkoff Electric Lighting Company; F. R. May, American Rapid Telegraph Company; T. J. Montgomery, Brush Electric Company; G. S. Mott, Bankers and Merchants Telegraph Company; H. W. Pope, Manhattan District Telegraph Company; C. W. Price, Baltimore and Ohio Telegraph Company; A. C. Richards, Automatic Signal Telegraph Company; J. Eliot Smith, Fire Department Telegraph; Elihu Thomson, American Electric Company. Representatives of the Gold and Stock Telegraph Company, the Mutual Union Telegraph Company, and the American District Telegraph have yet to be appointed. Mr. J. P. Davis was elected chairman, R. W. Blackwell treasurer, and H. C. Behrens secretary. Mr. Robert B. Minturn, in a short speech, said that he was confident that the present Bill compelling companies to place their wires underground would not pass the Legislature. It ought not to pass, because it was tyrannical and unjust. The companies were not unwilling, but unable, to accede to the popular demand, and they were ready to adopt any feasible system. Mr. William M. Ivins said that concerted, harmonious action ought to be taken at once to devise some practical solution of the problem. There were great difficulties in the way, and they should be carefully considered before any steps were taken. Remarks were also made by other gentlemen.

Perry v. International Ocean Telegraph Company.—Judgment in this case was delivered on Monday last by Lords Justices Baggallay, Lindley, and Fry. The suit was instituted in 1874, and the hearing before Vice-Chancellor Bacon occupied nearly a fortnight in June, 1881. The bill was filed by Mr. Horatio Justus Perry, an American citizen, against the International Ocean Telegraph Company (an incorporated American company of the State of New York), the West India and Panama Telegraph Company, and the India Rubber, Gutta Percha, and Telegraph Works Company, the case being as follows: In 1866 the plaintiff entered into agreements with the International Company, and the defendant, Charles Knap, under which he was to endeavour to obtain a concession from the Spanish Government for establishing a system of telegraphic communication between Spain and the Spanish West India Islands, Cuba, and Porto Rico. On obtaining such concession he was to assign a portion of the privileges conferred by it to the company, and the remainder to Mr. Knap, receiving in consideration a fixed sum from the company, and from Mr. Knap a moiety of the profits which he should derive from the sale of the portion of the concession assigned to him, it being then contemplated that the sale should be made to a company. The concession was obtained and assigned as agreed; the company paid the consideration agreed to be paid by them, but that which was to be given by Knap was not made good to the plaintiff, who alleged that it was now represented by £25,000 worth of shares in the West India and Panama Telegraph Company, and he prayed a declaration that he was entitled to those shares, and other relief. Under the concession from the Spanish Government the West India Company (a company promoted by the International Company) had the exclusive right of telegraphic communication between Cuba, Porto Rico, Panama, the Windward Islands, and Demerara. The plaintiff contended that Knap had been a trustee for the International Company, or at all events its agent; and that under the agreements of 1866 he had a charge on the concession and the fruits of it. The first contention having been abandoned at the bar, it was argued that by subsequent agreements the International Company had taken the place of Knap. It was further contended that there had been a wrongful sale to the West India Company, and that the plaintiff might waive the tort and take the fruits. Vice-Chancellor Bacon dismissed the bill, with costs, and the plaintiff appealed. Their lordships dismissed the appeal, with costs.

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A GUIDE TO PRACTICE IN THE SUBMARINE CABLE TESTING ROOM.

No. XXIII.

The staff arrangements in connection with the submergence of a cable depend on various conditions, such as the length to be laid, the situation of the line, the number of stations between which sections are to be laid, the order of laying, and other matters. A cable recently laid in South America required a very large staff, as there were so many stations, and there were, therefore, a great many shore ends and separate testing places. A long cable, such as an Atlantic line, would have two or at most three or four shore stations, and at two of these the staff would consist of four electricians at most, one of whom is chief, and should have good experience of the work. It is very desirable that all should know the mirror signals; there is sometimes a mass of correspondence between the ship and shore, and every minute is valuable. A staff of three assistant electricians is necessary on board besides the chief electrician who always accompanies the ship. The shore ends are laid on the first favourable opportunity after the ship arrives on the spot, and if, as often is the case, this operation is performed at some date earlier than the time fixed for the main length to be laid, the sea end is buoyed, and the other end, of course, brought into the testing room on shore, generally a wooden hut erected for the purpose. The instruments should be in position as soon as possible, and if they are landed at the same time as the shore end the electrician will get them arranged as quickly as may be, there being time for sufficient adjustment for a fair test whilst it is being laid, and the details can then be finally fixed more at leisure. But if the main length is to be laid as soon as the shore end is landed, the testing arrangements will have been previously made, that no delay may occur.

The proceedings on board and on shore are precisely the same for all long cables, though in some details a little variation may be seen in the instructions given by different chief electricians. The main object in all cases is to maintain a constant intercourse between ship and shore, and a continually recurring set of signals at short intervals to show that all is correct and the cable insulation always good. As regards those for whom we are more immediately writing, our suggestions will be divided into two parts, one relating to the work on board, and the other to shore station duty. These are very much the same, though not entirely so. The ship is the head-quarters, and all the instructions originate there—shore must rigidly obey ship.

The arrangements for maintaining communication between ship and shore cannot be better set forth than in the exact words of a sheet of instructions drawn up by the chief electrician for the laying of a long cable recently from Europe to the West. We venture to reproduce a portion of these sufficient for our immediate purpose, as they are remarkably clear and concise.

"The principal tests are taken on board ship, where the cable is connected for insulation test by deflection on ship's galvanometer. The deflections are recorded every minute and the first . . . (and certain other) minutes worked out in the ordinary way and recorded. The negative current will be put on at the exact hour and reversed every fifteen minutes.

"On shore the cable is connected to one side of a condenser, the other side of this condenser being connected through a speaking galvanometer (mirror) and signalling key to earth. Thus this galvanometer is always ready for receiving from ship. . . . The cable is also connected to the working contact of a single lever key, the other terminal being connected to earth through an astatic galvanometer, and the bar terminal to a condenser, the other side of which is to earth. At every five minutes, commencing at the second minute after the hour, the key is depressed for ten seconds, thus charging the condenser from the cable, causing a throw on ship's galvanometer, and serving for a continuity signal to ship; the key will then be released and the deflection on the astatic galvanometer recorded—the direction, left or right, depending on the current from the ship. . . ."

A plan accompanying these instructions would vary a little from the figure now given (Fig. 47), but in all respects the principle is the same. The shore station connections shown in this figure are rather squeezed to economise space, and the following points must be noted:—The galvanometer on the right (facing us) is connected to the four-way piece, and would be joined direct to earth by a wire from the vacant terminal; but sometimes this requirement is effected by the lead from the testing key T K which is seen with its end loose; the earth is then made through the upper bar and by the earth wire on the other terminal. The four arrow-heads placed together represent the means for introducing into the circuit the large condensers S C for speaking. They are at certain times disconnected, and we have, therefore, merely indicated their position. We will just go over the figure, referring where necessary to the instructions given above, there being some slight difference.

The round commutator marked D has five contact points, the cable being joined to the centre. Each of the four other connects to the centre point by a series, which, when put down, presses on a spring, and thus effects communication with it. When not screwed down there is no connection with the centre. One terminal has an earth wire, one has a lead for joining up to a Wheatstone bridge when required, one connects with the switch V, and the fourth is joined up to the Lambert key, which in

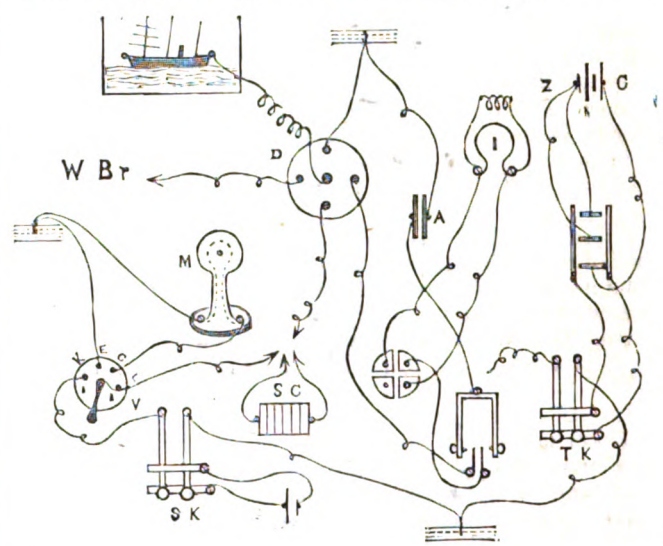

Fig. 47.—Connections at Shore Station, long Cable laying.

this figure replaces the contact key mentioned in the instructions. The condensers S C represent the condenser spoken of in that quotation as having the cable connected to it. Taking the plan from the right hand, we have the testing battery at the top, with the battery commutator below, and under it is the testing key T K, then the discharge key, the galvanometer and its commutator. On the left is the speaking key S K, the switch V, and mirror M, with the condensers ready for inserting. The small condenser A is the second one referred to in the instructions, and is of the same form as illustrated in a recent number, enabling us to use any amount from 1 up to 20 microfarads. The cable is supposed to be paying out from the ship in the far distance—any number of miles off. Turning now to the duties at the shore station, we will suppose that the shore end has been landed, and that a length of perhaps 100 knots has further been submerged on a separate expedition preceding that now before us. The sea end will be on board and the other end is all ready in the shore testing room, with all connections prepared for the main expedition. The chief electrician in the ship will give instructions as to the time when they expect to arrive at the spot where the cable is buoyed, and the electricians at the shore station must be on the alert for the important occasion. The shore end will have been landed in sufficient length to admit of a good quantity of spare cable. The portion emerging immediately from the sea

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is laid in a trench dug for it, and several large coils are then buried near the hut, leaving a length of a few fathoms to the end, which is then brought into the hut, and a few yards stripped of its sheathing and hemp covering, leaving the core exposed, and the end brought up to the table. A few inches of the gutta percha are stripped off, leaving the conductor so far bare. When joined up for the expected arrival of the ship at the buoy, the end is connected directly to the speaking mirror M, so that the slightest signal is at once received. In the figure the end is not so connected, the plan being intended to show the arrangement after the regular laying is begun. The ship will be brought to the buoyed end as nearly at daylight as can be managed; if the buoy is no further distant than a hundred miles west of the shore station the time will be nearly the same at both places. An assistant will therefore start watch at two or three hours before the time ordered by the ship, when the connections must be carefully looked over, and everything right. The spot of light from the mirror falls on a piece of white paper on a little stand, movable as required. The electrician on watch must keep his eye on this, and wait for the signal from the ship. The spot may not be perfectly steady at this time, hough in a length of 100 knots there may not be much disturbance from earth currents, but there need be no difficulty in this respect. The cable being joined to the mirror coil, and no battery being in acting circuit, the first sure sign of the ship having got the end will be given by the electrician on board sending a current through the line.

The spot will fly off the scale, and dart back and forward, the signals being small or large according to the number of cells used. Five or seven will probably be the number, but the first sign is always the same, being the call signal . . . — . The moment the assistant sees the movement he must disconnect the cable end from the mirror, and join it to K on the switch, at the same time joining the point G to the terminal from which he has removed the cable. He has now the means of answering as well as receiving signals. The leads will be in their places ready for these or other changes. He will now use his speaking key, S K, and answer the call by repeating the same sign. Ship will probably reply "decrease battery power," or the contrary as may be. We must therefore alter our battery by changing the negative lead from, say, the 7th cell to the 4th and then call ship, also ask him to increase or decrease in his turn if the signals are too small or too large. Ship then sends some messages and gives some orders, and then, when the cable has been spliced, orders regular testing to begin. The connections are now arranged as in the Figure 47. At the exact time to a second, as mentioned in the instructions above, the electrician on duty depresses the left-hand side of his discharge key for a moment, and then, releasing it, touches down the other side, carefully reading the deflection from the galvanometer, and entering it in the book before him. When ship reverses his current he will observe it, and particularly see if the time corresponds to a second with his own clock. This is seldom exactly the case; therefore, if, for example, he finds ship time one second faster than his he must count his five minutes from one second earlier than before, always keeping ship's time.

As long as all is well these continuity signals go on, with occasional interruptions for messages, some of which are periodical, giving ship's position, depth, length paid out, &c., but in cipher, as nearly all are, until it is necessary to splice on another length of cable on board. Ship gives warning of this, and advises the time when his current will be taken off. When that time has arrived, the spot disappears (and returns), and after some short interval, during which the cable is disconnected on board and the conductor is being jointed to that of the fresh length and the gutta percha laid over, ship calls again. The joint is so far completed as to allow of communication, and signals are interchanged whilst the splicing is being finished, a period of about half an hour. Ship also advises what changes are to be made, for instance, in the amount of condenser to be now used, &c., and, when ready, orders regular testing to recommence. Our space being so limited, we cannot prolong this account of the regular work. All goes on in the same way, unless an accident happens or a fault occurs. Sometimes the cable breaks suddenly, even in the middle of a message; observing the sudden stoppage of signals, shore must call for a certain time, and if he gets no answer must alternately put to earth and insulate the cable for, say, ten minutes each time (in case of ship being able to test), and join at times to the speaking mirror. He does this for some hours, when, having no signals, he will either connect the cable direct to the mirror as at first, or to a relay, so as to ring an electric bell if a current is sent through it, and also takes tests every hour. Days and weeks sometimes pass without communication, and watch must be constantly and ceaselessly maintained. It is safer to join direct to the mirror than to a bell, as earth currents often cause false alarms by ringing it. During the absence of communication it is well to observe these earth currents, watching their course, rise and fall, &c., and recording the facts. The hours of duty are divided as fairly as possible, but every one must be prepared for any length of watch, and in some positions accommodation is of the roughest. Cable huts are always in out of the way places, and necessarily so. Attention to "little things," as some persons sneeringly call them, is very important, such as making sure that the lamps are regularly filled and attended to. The spot of light is the tell-tale, and must be constantly maintained. Earth currents at certain times prevail in one direction for hours, then return, and act in the opposite

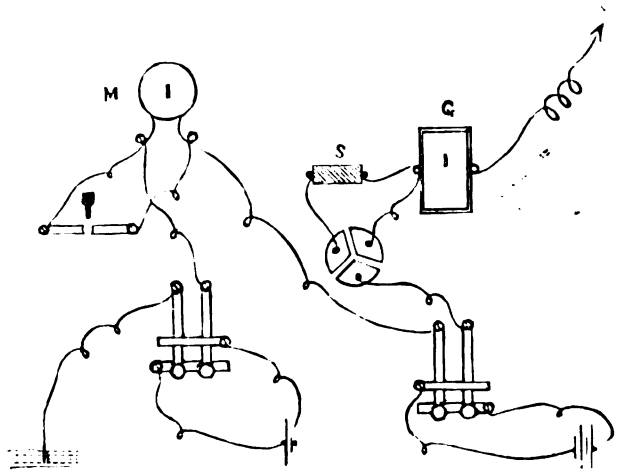

FIG. 43.—Connections on board during submergence.

direction. The spot is during these times pushed (so to speak) further and further, until it passes far off the little scale, indeed becomes invisible from the interception of the rays by the face of the mirror itself, as the actual mirror and little magnet are hung at the end of a hollow way, and the range of play for the light is small. Any way the spot disappears, and even the directing magnets of the mirror will not bring it back. It is necessary then to place a strong horseshoe magnet alongside the mirror stand, turning its poles in the proper direction to act on the little magnet inside, and so turn it back. The earth currents are at times very strong indeed, equal to many cells. If the assistant on duty observes irregularity in the signals he must look over his connections, and, if all is right, must advise ship, as perhaps there is a fault. The strong sign of this would be the continuity signals becoming smaller.

A word or two on the duties of the assistant on board. He has to watch and record the deflections every minute, as pointed out in the instructions. A constant is previously taken, by which the results are worked at stated intervals. The rolling of the ship and other causes produce a wandering, disturbed motion of the spot, very different from the steady deflection in this (insulation) test on shore. The number of divisions must be estimated as nearly as possible. The length being uniform, the deflections do not vary very much, but it is at times impossible to be sure of the figures. If any great irregularity of the signals appears, the electrician on duty

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must give the alarm (by sounding a gong is the best way), when the ship will be stopped, and a fault will be looked for and tests taken, or, if the cable is broken, the ship will grapple till it is picked up. The connections on board may be represented by Fig. 48. They explain themselves. We have added one more figure (Fig. 49), giving a plan of connections at a station for a shorter cable; where no good earth is available, the sheathing of the cable is made to do that duty.

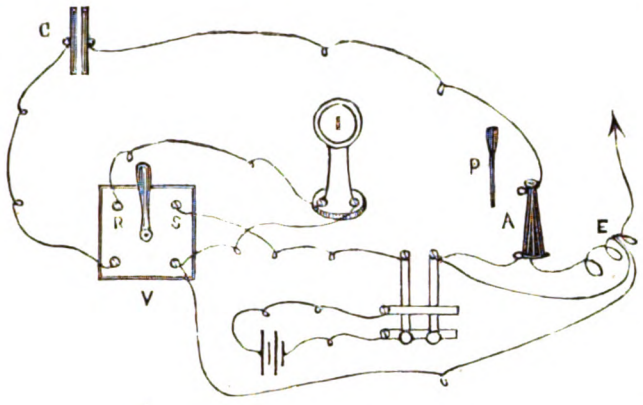

FIG. 49.—Connections on shore, earth on Cable.

Our series is unavoidably closed for the present. There are many important branches which remain for consideration, and we have been compelled to abridge our explanations, in some instances considerably. The subject, as far as it has reached, is appropriate to the requirements of one who has experience still to acquire.

F. S. BEECHEY.

ELECTRIC LIGHTING OF CANTERBURY.

Report of Mr. T. H. BLAKESLEY, Assoc. M.I.C.E., upon the (Draft) Provisional Order applied for by the South-Eastern Brush Electric Light and Power Company.

We have so often recommended municipal authorities to obtain the advice of competent men upon the schemes for lighting proposed for the districts under their supervision, and we think the opinions expressed in the reports of such competent men so important, that we do not hesitate to devote a considerable amount of attention to these matters. The report of Mr. Blakesley is fairly exhaustive, and his remarks should be read with the draft provisional order applied for. The latter is, according to law, published at a nominal price, but, of course, the report is a private matter between the authority and its adviser. We have to thank the Town Clerk of Canterbury and Mr. Blakesley for putting the report at our service.

Mr. Blakesley holds very strongly to the opinion that in no case should electricity be so supplied as to be applicable for one purpose only, and we entirely agree with this view. Gas as supplied may be used for lighting or heating purposes, or for use in a gas engine, &c. Mr. Blakesley says:—

"The granting of any monopoly for the supply of electricity would be, under any circumstances, only excusable if the electricity is supplied at a reasonable cost for all reasonable purposes to which it is applicable. It would be most unfair that any inhabitant should be debarred from obtaining for a reasonable price electricity suitable for mechanical application simply because the undertakers elect to supply electricity in a form under which it cannot be so employed, viz., in an alternating current. It would, again, be unfair to oblige a customer to employ a form of lamp of a more wasteful and uneconomical description than another only because the undertakers do not choose to maintain a proper and not unreasonable pressure in their mains. Now, although there is no monopoly directly sought, yet it seems to me probable that when the Brush Company shall have obtained the lighting of the City of Canterbury (presumably the most certainly remunerative part of the business of the district), no other company is likely to come into the city with an offer to supply electricity for other purposes than lighting. It is not likely that the attempt to do so would be commercially successful. At all events, if the Brush Company contends that there is a fair chance of such an attempt being commercially successful, there will be the less reason why the Brush Company should not be bound to supply electricity (at fair prices) for all purposes for which electricity may be required by the inhabitants of the city. If it should turn out that electricity is not wanted, except for lighting, there will be no injury inflicted on the Brush Company by inserting in the order proper provisions for compelling it to supply the want when it arises, but in the contrary event I submit that it will be very unfair to the public of Canterbury that the supply of electricity for other than lighting purposes should be dependent upon the will of the company, which will have established a practical monopoly for twenty-one years. The company should be prepared for all reasonable demands. . . . To meet this end, too, the company should be compelled to employ continuous currents, and for other reasons it is desirable to prevent the use, except under special agreement and under special conditions of insulation, of alternating currents. The alternating current can be used for little else than for lighting, and for this purpose a non-alternating current is as serviceable. Moreover, the alternating currents are dangerous, and the amount of energy supplied by them is not readily indicated by meter. The words 'alternating current' mean one in which the direction of the current is changed many hundred times, and even many thousand times, in a minute. Not only should the current be non-alternating in this sense, but the undertakers should be bound to keep the positive main at one time always positive and the negative main always negative. This is necessary for the due action of many lamps, of many dynamo machines, and of all storage batteries which may be used by consumers in connection with their supply."

It would have been better, perhaps, if the condemnation of "alternate currents" had been less sweeping. Those who have given great attention to the subject will not admit the impossibility of using alternate currents to transmit power, and it seems they are probably right, but the question as to the economy of the transmission of power by alternate currents in comparison with that by means of continuous currents has not yet been solved. Another important question is, if the electric light is to be introduced into a town, is it right that the undertakers should say thus far will we go and no further—the gas company may go further, but we choose the best paying part of the city, and do not mean to take bad and good together? The report on this head says:—

"I quite concur in the opinion which the Town Council have already formed, that there should exist some power to compel an extension of the streets mentioned in Schedule B, and I do this on the grounds I have given for demanding other alterations, viz., that there will be a practical, if not a nominal, monopoly established. I would go even further than the Town Council propose by amending Section 18 so as to include all streets in each district, or at least all in which gas has been consumed. By this means, after the Board of Trade has once issued a requisition for any particular district, the onus of praying for any modification would rest with the company and not with the Corporation. In principle I hold that it is right that the company should on reasonable terms be bound to supply their whole district. For it is only natural to expect that the profits of the gas company will show a diminution, at least during the time that the Brush Company's prices are put at a rate to bid for custom. And if the profits of the gas company are diminished, that company may take advantage of the sliding scale to raise the rates for gas, and thus the inhabitants of streets in which the undertakers may decline to supply electricity, although lying within their area of supply, may materially suffer. Having regard to the discretion which Section 18 leaves to the Board of Trade, I think that the whole of the streets in each section of supply ought to be included, or, if this would tax the powers of the company to too high a degree, then the districts should be reduced in area. It is more advantageous for the public that the powers of the company should be expended in providing electricity for all purposes and to all inhabitants in a restricted district rather than in purveying it for special purposes and to a limited extent over a wider area."

The author seems to think that in time the "series" system, or a modification of it, will be introduced into house-lighting, and suggests fuller details if this plan is to be adopted. Although the series system seems to lend itself to economy, we doubt not that its disadvantages are too great to lend itself to household lighting. The minimum E.M.F. in the mains, 30 volts, is regarded as absurd; but we are not sure that even this low E.M.F. might not be found useful, not for 16 candle-power or

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20 candle-power lamps, but for 2 or 5 candle-power lamps to be used in bed rooms, nurseries, &c. The author is of opinion—

"That a consumer should have a pressure of 100 volts at his poles, which would enable him to employ the economical Edison lamp of 32 candles, should he desire to do so.

"I think it desirable, therefore, taking into consideration the reductions the powers of the undertakers enable them to make, the minimum pressure at the mains should be one hundred and fifteen instead of thirty. I have to point out another matter in this section. If the standard pressure is to have a different value at different hours, a wrong will be liable to be done to the consumer should the undertakers elect to charge him by any but the first method of Schedule 6, in which case no obligation is put upon the undertakers to consider the varying character of the standard pressure in estimating the energy to be charged to the consumer. Section 22 (*b*) should be further amended as follows, viz., by omitting all after the word 'mains' in line 16, page 9, and substituting the following:—'But unless the undertakers charge the consumers by meters registering directly the energy supplied, the standard pressure for any pair of corresponding points of the said mains shall not vary at different hours during the period of supply,' or words to the same effect."

The figures quoted in the report are those given in Crookes's report on the lamps at the Paris Exhibition, and it is but just to point out that considerable adverse criticism has been offered to this report. It has been said that, *e.g.*, the Swan lamp is normally of 20 candle-power, the Edison 16 candle-power, and, therefore, any comparison of Swan at 16 candle-power with Edison at 16 candle-power, is necessarily against the former, and so on in other cases. In discussing the charge for electricity the author says:—

"The energy of electricity, which is the valuable commodity for which the company is going to ask you to pay, differs from gas in the following important particular:—Presuming that the gas pipe is perfect and that there is no outlet for a certain length, we know that whatever gas passes into that section at the one end passes out again at the other. But in the case of electricity the passage along any conductor necessarily absorbs the energy of the electricity to an amount depending upon the nature of the conductor and its size, but very well understood. The greater the resistance the greater the loss. Thus the house services and the meters and fuses and other apparatus through which the current may pass, all absorb energy for which the consumer must pay. Now Section 21, Clause (*d*), allows the undertakers to put down service lines (under which term is not included any meters, fuses, or other apparatus), which, in effect, will absorb 5 per cent. of the energy which is used between the junctions of the house lines with the distributing mains. Thus on this account alone 5 per cent. of energy is generated by the undertakers merely to sell it. This may be taken as all waste, for if the house line were constructed properly the resistance would be inappreciable. It will be quite necessary, therefore, to include the meters, fuses, &c., in the meaning of the words 'service lines," for the purposes of this clause. Further, as some meters have an effect in reduction of the pressure at the poles, which is not only of the nature of resistance, it will require to be taken into particular consideration."

Alterations in the order are suggested. Why should the consumer pay for this loss if it is to amount to 5 per cent.? But, again, why should it amount to 5 or ·005 per cent.? If loss there must be, then in the long run the consumer will have to pay; but we should prefer the payment for loss to be indirect, just as is the payment for gas leakage.

"But, further, Clause (*c*) of Section 21 enables the undertakers to diminish the pressure at the mains 10 per cent. from the standard pressure without taking it into account in the estimate of energy to be paid for, which will be reckoned as if the pressure was kept up to the standard pressure. Now, the energy expended between the junctions of the mains is the product of three things. The first is the pressure at the mains, the second is the current which, when the resistance remains the same (and the consumer, by Section 63 (*f*), is forbidden to reduce it on the pressure falling below the standard), is proportional to the first factor, viz., the pressure. The third factor is merely the time during which the flow goes on. It will be clear, therefore, that if the pressure becomes $\frac{90}{100}$ of the standard, the current becomes $\frac{90}{100}$ of what it would be under standard pressure, and the resulting energy is on this account $\frac{90}{100} \times \frac{90}{100} = \frac{81}{100}$ of what it would be if the standard pressure is maintained.

The effect of the Clauses (*c*) and (*d*), taken together, will therefore be different according to the method of estimating the energy adopted by the undertakers.

In the table below I have arranged the three quantities viz.: 1st. The energy consumed between the consumer's poles taken as one hundred; 2ndly, the energy consumed on his house lines and between his poles; and lastly, the energy he is charged for. If the undertakers are allowed to absorb the 5 per cent., besides an unknown quantity in meters and fuses, the case is so much the worse. It will be observed that if the first method is chosen, *i.e.*, if the actual energy is measured, the case is least unfavourable to the consumer. There is one objection to its being adopted, viz., there is no energy meter. The second case is distinctly worse for the consumer. Under this method the quantity of electricity may be measured, and when multiplied into what the pressure ought to have been, *i.e.*, the standard pressure, the product reduced to the proper number of units will be the energy charged for. Thus, for every hundred quantities of energy which the consumer has really employed usefully, he pays for 16·96 more, of which 5·26 has been supplied but consumed in the house lines, and 11·70 has not been supplied at all, and the price for which goes into the undertakers' pockets. But there is a third method. The meter in this case measures only the time the supply has lasted. It may be in the form of a watch which, by means, perhaps, of a magnet loosening a catch, goes on while the current is flowing, but quite independently of the strength of the current. In this case the pressure and the current both are to be estimated as if the standard pressure were maintained. They may both be only 9·10ths of these values. In this case for every 100 quantities of energy which the consumer has really employed usefully he pays for 129·95, of which 5·26 has been supplied and consumed in the house service, and 24·69 has not been supplied at all, though the price for it goes to the undertakers. The fourth method of charging will be worse than the third unless the consumer takes the current during more than eighteen hours per day, which is very improbable. Not only is the margin allowed in the estimate of the energy consumed very excessive, but the actual price of the energy is very high. It is true that there is at present but little experience in the question of the cost of such undertakings, but if the uncertainty prevailing on the subject be a reason for allowing a high maximum charge to the consumer it is also a reason for imposing a sliding scale by which that maximum may be lowered upon a certain amount of profits being earned. But there is by no means absolute uncertainty on the subject. Dr. Siemens has estimated that electrical energy can be produced at a cost of less than 1¼d. for each of those units for which the Brush Company propose to charge 8¾d. or 7d. After making every reasonable allowance it is difficult to see how the proposed prices can fail to leave enormous and excessive profit to the undertakers. I therefore recommend that a sliding scale should be introduced by which an 8 per cent. dividend should be made contingent on a supply of energy at 3d. per unit. In Section 39 the undertakers seek to put obstacles in the way of the use of secondary or storage batteries in certain cases. There is nothing in this clause that is at all beneficial to the undertakers, and much that is inconvenient and vexatious to the consumer. I beg to point out that it is not proposed to exclude the use of dynamo machines, but only of storage batteries. Now, the action of these batteries upon the system while they are being charged is precisely the same as that of dynamo machines, the difference to the customer being that in the case of storage batteries he has the power to use the energy given into them when he wishes, whereas in the case of the dynamo machine he must use it at once. Why should he not use the energy supplied to him, and to be paid for by him, in other than the hours of supply? There is no good reason why he should not do so. . . . When it is taken into consideration how extremely useful storage batteries would be in the case of any break down in the supply contemplated by the undertakers themselves as liable to occur, I submit that this section is not only unreasonable but oppressive, and recommend that it be struck out."

ENERGY.

Method of Charge.	Consumed between the poles of consumer.	Consumed between junctions with main.	Charged for.
First method	100	105·26	105·26
Second method	100	105·26	116·96
Third method	100	105·26	129·95

The report favours a continuous supply, and recommends the consumer to "buy" power and not current—that is to pay for "watts," not "amperes," and contends that by so doing he is less likely to be overcharged. We think we have indicated the most important features of this report, and will only add that when "energy meters" are wanted no doubt they will be forthcoming.

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THE INSTITUTION OF CIVIL ENGINEERS.

The last of the series of lectures on the Practical Applications of Electricity, being on "Electrical Units of Measurement," by Sir William Thomson, F.R.SS. Lond. and Edin., M.Inst.C.E., was delivered on Thursday evening, the 3rd of May, 1883.

The lecturer began by observing that no real advance could be made in any branch of physical science until practical methods for a numerical reckoning of phenomena were established. The "scale of hardness" for stones and metals used by mineralogists and engineers was alluded to as a mere test in order of merit in respect to a little understood quality, regarding which no scientific principle constituting a foundation for definite measurement had been discovered.

A short historical sketch was given of the development of scientific measurement, as applied to electricity and magnetism, from its beginning with Cavendish, about 100 years ago, to the adoption of the absolute system of measurement by this country in 1869, at the instance of the British Association Committee on Electric Standards. The importance in this development of the originating works of Gauss and Weber was pointed out, as also of the eight years' labours of the British Association Committee. This committee not only fairly launched the absolute system for general use, but also effected arrangements for the supply of standards for resistance coils, in terms of a unit, to be as nearly as possible 109 centimetres per second. This unit afterwards received the name of the ohm, which was adopted from a highly suggestive paper which had been communicated to the British Association in 1861, by Mr. Latimer Clark and Sir Charles Bright, in which some very valuable scientific methods and principles of electric measurement were given, and a system of nomenclature—ohmas, kilohmas, farads, kilofarads, volts and kilovolts—now universally adopted with only unessential modification, was proposed for a complete system of inter-dependent electric units of measurement. At the International Conference for the Determination of Electrical Units, held at Paris in 1882, the absolute system was accepted by France, Germany, and the other European countries, and Clark and Bright's nomenclature was adopted in principle and extended.

Gauss's principle of absolute measurement for magnetism and electricity is merely an extension of the astronomer's method of reckoning mass in terms of what may be called the universal gravitation unit of matter, and the reckoning of force, according to which the unit of force is that force which, acting on unit of mass for unit of time, generates a velocity equal to the unit of velocity. The universal-gravitation unit of mass is such a quantity of matter, that if two quantities, each equal to it, be placed at unit distance apart, the force between them is unity.

Here mass is defined in terms of force and space, and in the preceding definition force was defined in terms of mass, space, and time. Eliminating mass between the two, it will be found that any given force is numerically equal to the fourth power of the velocity with which any mass whatever must revolve round an equal mass, fixed at such a distance from it as to attract it with a force equal to the given force. And, eliminating force between the two primitive definitions of the universal-gravitation system it will be found that any given mass is numerically equal to the square of the velocity with which a free particle must move to revolve round it in a circle of any radius, multiplied by this radius. Thus, take a centimetre as the unit of length, and a mean solar record as the unit of time, and adopt 5·67 grammes per cubic centimetre as the mean density of the earth from Baily's repetition of Cavendish's experiment, and suppose the length of the seconds' pendulum to be 100 centimetres, and neglect the oblateness of the earth and the centrifugal force of its rotation (being at the equator only $\frac{1}{289}$ of gravity) the result for the universal-gravitation units of mass and force is respectively 15·36 French tons, and 15·36 dynes, or 15·07 times the terrestrial surface weight of a kilogram.

The ultimate principles of scientific measurement were illustrated by the ideal case of a traveller through the universe who has brought with him on his tour, no weights, no measures, nor watch or chronometer, nor any standrd vibrator or spring balance, but merely Everett's units and constants and a complete memory and understanding of its contents, and who desires to make for himself a metrical system agreeing with that which he left behind him on the earth. To recover his centimetre the readiest and most accurate way is to find how many wave lengths of sodium light there are in the distance from bar to bar of a plating which he can engrave for himself on a piece of glass. How easily this is done, supposing the grating once made, was illustrated by a rapid experiment performed in the course of the lecture, without other apparatus than a little piece of glass with 250 fine parallel lines engraved on it by a diamond, and two candles and a measuring tape of unknown divisions of length (only used to measure the *ratio* of the distance between the candles to the distance of the grating from either). The experiment showed the distance from centre to centre of consecutive bars of the grating to be thirty-two times the wave length of yellow light. This being remembered to be $5{\cdot}89\times10^{-5}$ of a centimetre, it was concluded that the breadth of the space on which the 250 lines are engraved is $250.32.5{\cdot}892.10^{-5}$, or ·4726 of a centimetre. According to the instrument maker it is really ·5 of a centimetre! Five minutes spent on the experiment instead of one, and sodium flames behind fine slits, instead of open candles blowing about in the air, might easily have given the result within one-half per cent. instead of 4½ per cent. Thus the cosmic traveller can easily recover his centimetre and metre measure. To recover his unit of time is less easy. One way is to go through Foucault's experimental determination of the velocity of light.

But, he must not be imagined as electrically-minded; and he will certainly, therefore, think of "v," the number of electrostatic units in the electro-magnetic unit of electricity; but he will, probably, see his way better to doing what he wants by making for himself a Siemens mercury unit (which he can do easily, now that he has his centimetre), and finding (by the British Association method, or Lorenz's with Lord Rayleigh's modification, or both) the velocity which measures its resistance in absolute measure. This velocity, as is known from Lord Rayleigh and Mrs. Sidgwick, is 9,413 kilometres per mean solar record, and thus he finds, in mean solar seconds, the period of the vibrator, or arbitrary-unit chronometer, which he used in his experiments.

Still, even though this method might be chosen as the readiest and most accurate, according to present knowledge of the fundamental data for recovering the mean solar second, the method by "v" is too interesting and too instructive in respect to elimination of properties of matter from our ultimate metrical foundations to be unconsidered. One very simple way of experimentally determining "v" is derivable from an important suggestion of Clark and Bright's Paper, referred to above. Take a Leyden jar, or other condenser of moderate capacity (for example, in electrotastic measure, about 1,000 centimetres), which must be accurately measured. Arrange a mechanism to charge it to an accurately measured potential of moderate amount (for example, in electrostatic measure, about 10 c.g.s.; which is about 3,000 volts), and discharge it through a galvanometer coil at frequent regular intervals (for example, ten times per second). This will give an intermittent current of known average strength (in the example, 10^5 electrostatic c.g.s or about 1/300,000 c.g.s. electro-magnetic, or 1/30,000 of an ampere), which is to be measured in electro-magnetic measure by an ordinary galvanometer. The number found by dividing the electrostratic reckoning of the current, by the experimentally found electro-magnetic reckoning of the same, is "v," in centimetres per the arbitrary unit of time, which the the experimenter in search of the mean solar second has used in his electrostatic and electro-magnetic details. The unit of mass which he has chosen, also arbitrarily, disappears from the resulting ratio. It is to be hoped that before long "v" will be known within 1s. 10d. per cent. At present it is only known that it does not *probably* differ 3 per cent. from $2{\cdot}9\times10^{10}$ centimetres per mean solar second. When it is known with satisfactory accuracy, an experimenter, provided with a centimetre measure, may, anywhere in the universe, rate his experimental chronometer to mean solar seconds by the mere electrostatic and electro-magnetic operations described above, without any reference to the sun or other natural chronometer.

The remainder of the lecture was occupied with an explanation of the application of the absolute system in all branches of electric measurement, and the definition of the now well known practical units founded on it, called ohms, volts, farads, microfarads, amperes, coulombs, watts. The name mho, found by saying ohm to a phonograph and then turning the drum backwards, was suggested for a unit of conductivity, the reciprocal of resistance. The subdivision, millimho, will be exceedingly convenient for the designation of incandescent lamps.

The British Association unit has been found by Lord Rayleigh and Mrs. Sidgwick to be ·9868 of the true ohm (10^9 centimetres per second), which differs by only 1·50 per cent. from ·9870, the number derived from Joule's electro-thermal measurements described in the British Association Committee's report of 1867, with 772 Manchester foot-pounds taken as the dynamical equivalent of the thermal unit from the measurement described in his Royal Society paper of 1849, and confirmed by his fresh measurement of 20 years later, published in his last Royal Society paper on the subject.

It is satisfactory that, whether for interpreting old results, or for making resistance coils anew, electricians may now safely use the British Association unit as ·9868, or the Siemens unit as ·9413, of the ohm defined as 10^9 centimetres per second.

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THE ELECTRICIAN.

TO CORRESPONDENTS.

All letters intended for insertion in THE ELECTRICIAN, *or containing questions, must be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever will be taken of anonymous communications.*

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INDEX TO VOL. X.

With our present issue we publish an index to the volume of which it forms the last number, viz., Vol. X. Each number as issued from this office contains this index, consisting of eight pages, and no extra charge is or should be made for it.

LONG DISTANCE TELEPHONY.

The startling advertisement which appeared at portentous length in the newspaper columns one day last week, inviting subscriptions to the Long Distance Telephone Company, will have aroused very conflicting emotions in the breasts of persons interested respectively in existing telegraph and telephone affairs. To both alike the incident must have been somewhat alarming—at all events until the next morning. Local telephony has not yet accomplished long distance telephony to any appreciable extent, nor has it promised to do so. It does not, in fact, include long distances in its programme. Now a long distance telephone company, on the other hand, may be supposed to include short distance telephony from the very outset, and thus presents itself not merely as doing something more than the existing companies do, but all that they are able to do besides. Its prospectus, therefore, is not very cheering news for local telephony.

To the Telegraph Department the announcement of a formidable rival being in the field is perhaps more irritating than alarming. Just when the Chancellor of the Exchequer has been so provokingly zealous as to require them to risk the loss of a quarter of a million or so per annum in reducing their tariff, the officials are confronted with another caterer for public favour, and one which, if a third of its expectations are realised, will swell their losses still more. Those expectations may not be realised—they may not even be allowed to have a chance of being realised; but then there is the trouble, and vexation, and odium attached to preventing them doing so by force of law; and the Government had quite enough of that kind of experience when it fought its battle with the original telephone companies. At the moment of our writing it is by no means certain that this long distance telephonic project will be floated; but if it be floated its capital of £600,000, even after the vendor has received his handsome allotment of £175,000 in shares, will afford ample margin for entering the Courts of Law with a light heart, confident in the assurance of bringing the Government into discredit, and of winning the public over to the side of the enterprising competitor. Such a contingency cannot be contemplated with perfect indifference, we may imagine, even in the dignified precincts of the General Post Office.

From another point of view, however, the Postal Telegraph Department cannot fail to get some sort of comfort out of the appearance of this threatened rivalry. It justifies their action in the matter of the telephone companies, and more than warrants their having asserted the right of the Government to the monopoly which, at the instigation of the public, it acquired for the public benefit. The assertion of that right was by no means too emphatic, considering the public revenue at stake; nor has the exercise of it been in any way, so far as can be discovered, detrimental to public convenience, or to private enterprise. What the department has lost by the introduction of telephony and by its being conducted for profit chiefly by competing companies instead of by the telegraph administration it is impossible to say. One thing, however, is made pretty clear by the prospectus now before us—that the risk would have been greater and the loss more certain if the original meaning of the Telegraph Acts had not been upheld in a court of law. Matters are made simpler by that decision, and probaby safer, though in view of the uncertainty of the law it is impossible to say that they are made quite sure.

The thorough-going denouncers of Government monopoly will, one may be permitted to hope, experience an interval of rational reflection. They can hardly avoid seeing that their arguments have been pushed to their logical and ridiculous conclusions by this Long Distance Telephone Company. If a telephonic message is not a telegram over a distance of two or three miles, it can hardly be said to be a telegram if it annihilates space and time, to quote the words of the prospectus, in bridging a distance which, in common language, is described as two or three hundred miles. There is no essential difference, one would imagine, between a short speaking wire run over a few house tops inside a town, and a long speak-

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ing wire erected on a thousand poles alongside the railroad. Lastly, there is nothing to choose, from a logical point of view, between a thick wire and a thin one, between copper and iron, or between a patent of one telephone and a patent of another telephone. Yet if the arguments current at the time of the first great telephone suits were sound and good for the case they were then put forward to support, they are sound and good for the purposes of the Long Distance Telephone Company. We should not be greatly surprised if the very people who were foremost in asserting that a telephone was not a telegraph are now the first to discover that a telephone is not a telephone if it speaks beyond the area of an "Exchange."

We have no wish to discount the merits of the inventions, whatever they may be, which have justified the promoters of the new company in starting so formidable a scheme; nor can any reasonable objection be taken to the scheme itself, as such. If we are now able to telephone over long distances as easily as over short distances, by all means let it be done. Even if, as may possibly be the case, the expense be far greater, the public may be willing to incur it for the extra convenience, and there is no harm in their being allowed to do so. If we might take exception to anything in this prospectus, perhaps it would be, firstly, to the absence of explicit statement as to cost, say, of ordinary telegraph wires, compared with that of extraordinary telephone wires; and, secondly, the presence of a quotation from a statement of Mr. Fawcett in the House of Commons, made with reference to a quite different matter, but here reproduced for the obvious purpose of anticipating objections to the new scheme on the score of its clashing with the views of the Department over which Mr. Fawcett is the head. In other respects, the document is candid enough—almost too candid; for it tells us that the promoters intend to erect wires between London and most of the important towns in the kingdom, and that it will put the people of these places in communication with each other at the rate of, say, one shilling for every five minutes' conversation. Sixpenny telegrams will have uphill work to compete with telephone "conversation" at that rate, and we should fancy that if the Postmaster-General were again interrogated on the subject he might not be quite so ready to "favourably entertain" proposals for licenses coming from a quarter so unlooked for and so threatening.

CORRESPONDENCE.

ELECTRIC LIGHTING OF NOTTINGHAM.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I have read with very great interest the specification and tender for the electric lighting of the borough of Nottingham which appeared in your last issue. I regard the publication of this tender as an epoch in the history of electrict lighting. Remarks which I have already heard indicate that it has awakened a new interest in the subject. After all we have heard of bubble companies, dividends from the sale of concessions instead of honest work, and cheap installations intended to bring an indirect profit through the medium of the Stock Exchange, a genuine tender from such a company as the Telegraph Construction and Maintenance Company is especially valuable, and will do more than almost anything else to establish public confidence. Every one knows that a tender from such a company is based upon true commercial principles, and calculated to return a fair profit to the contractors, and that if unforeseen difficulties should occur the company would carry out their contract, even if it cost them twice the sum stipulated.

One point which this tender demonstrates very clearly is the fact that the total cost of lighting a large town is much less than has been supposed by some persons, and it proves this in the best possible manner—viz., by bringing forward a responsible company willing to undertake the work at the price named.

Taking the engines, boilers, dynamos, &c., as specified, and assuming everything to be the best of its kind, the capital cost of the installation seems reasonable enough, and I have no reason to doubt that it would pay a fair profit to the company. I agree with you in thinking that the limit of 1,750 amperes per square inch of main is far too high. In an installation of this sort the section of the mains must be determined upon the score of economical working, and not simply from the consideration of not overheating the conductors. In an installation in which the *mean distance* of the lamps from the dynamo is 300 yards, I think the current should certainly not exceed 1,000 amperes per square inch. The fulfilment of this condition will slightly increase the cost of the installation.

I have, however, found a few difficulties in endeavouring to adapt the comparison of the working expenses of the installation with the cost of gas to the case of ordinary non-manufacturing towns, such as those with which I am most familiar. Of course, only those who have a local knowledge of Nottingham, can tell whether the great consumption of gas in the factories or warehouses justifies the figures given in the appendix to the specification. I shall therefore assume that the figures are strictly accurate for the district to which they refer, which is well known to be of a very special character, and simply state my difficulties, in the hope that some of your readers who have a practical knowledge of the working of electric light installations as applied to towns, or more information than I can give respecting gas distribution, will be able to correct my conclusions, and solve my questions. In bringing forward these difficulties I am actuated by the belief that the best thing to favour the development and adoption of the electric light is the full and free discussion of every point connected with it. I believe that it will be the light of the future, and that in many localities it is qualified to be the light of the *present*.

I may notice, in passing, the question of water for the condenser. At the low rate of 5d. per 1,000 gallons, the condensing water required for 6,360 horse-power for 2,500 hours would amount to at least £10,000 per annum. This, of course, means that a cooling pond *must* be employed, though it may be at a distance of a couple of miles, and a separate engine must be used for raising the condensing water.

I propose now to consider a town of 180,000 inhabitants, which is, I think, of the same order of magnitude as Nottingham, but I shall exclude from consideration all large manufacturing establishments. Such establishments are, of course, a great advantage to the electric light undertakers, but the advantages to be derived from them can be readily determined in each town by those having the requisite local knowledge.

The total annual consumption of gas by a town of 180,000 inhabitants, excluding factories, may be taken to be about 900,000,000 cubic feet, or at the rate of about 5,000 cubic feet per head. The gas rental from this at 2s. 6d. amounts to £112,500. Such a town would cover an area which ought to be supplied from about ten separate centres.

The lights may be divided into (I.) street lights, (II.) business lights, (III.) lights employed in public houses, theatres, and similar establishments which are opened regularly after ordinary business hours, (IV.) lights in churches and other places of public assembly used occasionally, and (V.) private lights.

(I). The street lighting is easily disposed of. For 180,000 inhabitants rather more than 3,000 street lamps would be required, using about 50,000,000 cubic feet of gas per annum (allowing Bray's or Suggs's lamps in the main thoroughfares), and the rental would be (for gas alone) £6,250.

(II.) Respecting the relative number of lights in private

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houses, and in shops, offices, and other business establishments, I have no accurate information, and should be glad if some of your readers could enlighten me. Perhaps we shall not be far out if we assume that 200,000,000 cubic feet are employed in ordinary business establishments. From inquiries made in a large business town during the last few days, it appears that the average number of hours per annum during which the lights in ordinary retail business establishments in a provincial town are burning is about 700. This means that about 56,000 lights would be required for business purposes to attain the above consumption. The electric light undertakers must be prepared to light all these lamps at one time, and the income derivable from them would be £25,000 per annum.

(III.) The number of lights in public houses, theatres, and other establishments which are open till a late hour will probably be something like 12,000, burning 60,000 feet of gas an hour, and running for nearly 2,000 hours per annum on the average. The consumption on this score will, consequently, amount to about 120,000,000 feet per annum, with a gas rental of £15,000, or 25s. per lamp.

(IV.) The consumption in churches, chapels, lecture halls, &c., which are open occasionally, may amount to 12,000,000 cubic feet, with a rental of £1,500. The lighting of these buildings will not require any increase in the plant of the engine house, since when churches and chapels are requiring light the business and domestic consumption is small, while lectures, concerts, &c., generally take place after ordinary business hours, and also entail a diminution of domestic consumption.

(V.) Private or domestic lights. Subtracting from our 900,000,000 cubic feet the amounts required for the purposes above mentioned, we have remaining for domestic consumption 518,000,000, producing a rental of £64,750 per annum. It is not easy to determine how many private lights may possibly be going at one time. In my house there are about 45 lights, the number burning ordinarily from dark till 10:30 p.m. is about 11. From 10:30 till 12, about 4, and after that the consumption is negligible. Occasionally the number of lights burning at once is 20, and two or three times a year it may exceed 30. On these last occasions, however, it may be assumed that a number of persons are present and their own domestic consumption reduced. Taking a large area together, it would be safe to provide for the lighting of only 15 lamps in a house like mine, though 45 might be wired, assuming that when more are burning in one house there will be less in another. If I resided at home all the year, my gas consumption would be about 75,000 cubic feet, or 5,000 feet per light per annum. Though in different districts the actual number of lamps in a house may bear very different ratios to the number used at any one time, we may, I think, conclude that for every 5,000 feet of gas consumed per annum in domestic lighting the undertakers of an electric installation must be prepared to light one lamp, or, for a consumption of 518,000,000 cubic feet of gas they must be prepared to light simultaneously 103,600 lamps. The total number of lamps wired in the town might be from two to three times this number.

Hence we conclude that for a town of 180,000 inhabitants lighted entirely by electricity, the undertakers must be prepared to provide sufficient current for 3,000 + 56,000 + 12,000 + 103,600 = 174,000 lamps. The installation, or series of installations, would, therefore, be of about three times the extent of that proposed for Nottingham, while the return would be £112,500 if the electric light is charged for at the same price as gas, at 2s. 6d. per thousand. Factories, mills, warehouses, and workshops of all descriptions would, of course, tell strongly in favour of the electric light.

Judging from the tender of the Telegraph Construction and Maintenance Company, the capital cost of this installation spread over eight or ten centres would probably be very nearly £1,000,000, which does not differ very widely from the value of a gas undertaking capable of supplying the same area.

From the figures just given it appears that the electric light is not much behind gas for price, even when the latter is sold at the low rate of 2s. 6d. But there are very few towns which are not manufacturing towns in which gas is sold at so low a price. The greatest enemy to the commercial success of an electric light installation is the early closing movement, and the enormous number of lights employed in retail business establishments and burning only for 700 hours in the year.—Yours, &c.,

M. N.

May 9, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of the 5th inst., under the head of "The Cost of Electricity," you say that the figures given by the Telegraph Construction and Maintenance Company, in their estimate for the Nottingham electric lighting, show a result which surprises you, but which you, after careful consideration, are unable to modify.

Permit me to say that, as far as my information goes, the said estimate is of far too sanguine a character in respect of the income to be derived from the sale of electricity for lighting purposes. An error exists in the assumption that the whole of the 60,000 lamps which the plant is capable of working at once will be used for 2,500 hours per annum. I respectfully submit that no such result is likely to be obtained.

In view of the laying down of the Birmingham Electric Lighting Plant for the Incandescent Electric Lighting Company, Limited, I have caused a most careful house-to-house inquiry to be made of the number of gas burners in use, and the actual revenue derived from them. In only two or three instances has information been withheld, and the results may, therefore, be relied upon. The inquiry has been made throughout the whole of the "specified streets" in Schedule A of the provisional order, that is, those streets in which the undertakers will be compelled to lay down mains within two years after the passing of their Act. Sixteen thousand four hundred gas burners have been counted in these streets, and the mean earning per annum is 10s. 10d. per burner. The earnings vary from 43s. per burner for such premises as underground restaurants, which require artificial light all the time they are open, to 3s. per burner for banks, professional chambers, and the like. The 16,400 burners are situated in the best streets of the town, and on dark afternoons in winter nearly all of them are for an hour or two burning at the same time.

To substitute electric lamps for such burners it will be necessary to put down a plant capable of working nearly all of the lamps at once, or, at the very least, two thirds of them, whereas the annual earnings cannot be greater than those of the present gas burners, unless consumers will pay a higher lamp rental for electricity than for gas. For my own part I fully believe that they will do so, for, in addition to the personal advantages due to living and working in a pure and cool atmosphere, they will find a direct monetary saving in respect of less frequent redecoration of interiors of premises, and absence of damage to goods in stock, books, &c. But, taking the Telegraph Construction and Maintenance Company's estimate of a charge per burner hour equal to that of gas, it will follow that if the Birmingham data may be applied to Nottingham (and I see no reason to suppose that large towns will differ much from each other in this respect), the estimate will stand thus:—

A plant capable of running 60,000 lamps at once *may* represent a gross number of 90,000 lamps wired.

The revenue from 90,000 lamps at 10s. 10d. per annum each will be £48,750, instead of the £93,750 set down in the company's estimate.

The average price of gas being in Birmingham about 2s. 6d. per 1,000ft., it follows that a mean annual earning of 10s. 10d. represents a user of 866 hours per annum instead of the 2,500 hours assumed by the Telegraph Construction and Maintenance Company.

Of course the consumption of coal, water, &c., for electric lighting will be considerably reduced if 800 hours running be substituted for 2,500 hours, but many of the other expenses will remain unaltered, and the net result will be much less than that of the company's estimate.

In many cases a large supplemental revenue may be looked for from the sale of electricity for motive power purposes, but

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this advantage will be enjoyed only by those companies which use continuous currents. Vendors of alternating currents will have to depend solely upon lighting business.—Yours, &c.,

HENRY LEA, Consulting Engineer.

Birmingham, 7th May, 1883.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In response to your request I venture to submit a few considerations indicating the fallacies which underlie the statement of revenue and profits in the very interesting proposal for a large installation at Nottingham.

As no area is given, nor have I the space marked out on "the map of the district," it is impossible definitely to challenge the particulars leading to a supposed annual revenue of £93,750. We may, however, for the purpose of comparison, compare the area or parish with such a one as St. Martin's-in-the-Fields, in London, which, bounded by the river, extends north as far as Coventry-street, and, commencing at Parliament-street, ends at White Hart-street, Covent Garden. It embraces, therefore, *inter alia*, Whitehall, St. James's Park, Charing-cross, the Haymarket, and nearly all the Strand.

Now, the Nottingham district is to have "60,000 lamps," with an annual revenue of £93,750, whilst an important parish like St. Martin's *possesses only* 980 public lamps, and its gas bill is under £3,000 a year!

But it will be urged that "60,000 lamps" is intended for all private and public purposes within the district. Are we, then, to suppose that gas is to be suppressed, and manufacturers, millowners, and all private persons in the district compelled to exchange it for electric light? Certainly not, for the calculations of "2,500 hours from *sunset* to sunrise" clearly indicates that it is *public lighting alone* that is really contemplated. Again, by calculation it is found that if gas is lit at sunset, and extinguished at 11 p.m., a period of 1,805 hours is reached. So that the 60,000 cannot be intended for private lighting; for, as no one lights up at sunset, or would pay for his illumination "from sunset to sunrise," it is clear that, instead of 2,500 hours' consumption, the very outside would be 1,500 or 1,600 hours.

Allow, however, in the Nottingham district, 1,000 lamps for public use, burning from sunset to sunrise, and we have 59,000 left to be placed so as to average 1,500 hours each, a quantity of gas jets, I do not hesitate to say, that does not already burn in the Nottingham district continuously for 1,500 hours each. Now, no one conversant with existing gas illumination will agree that each jet burns "five cubic feet per hour, giving 12 or 14 candle-power." The plugging up of the pipes and nipples with dirt and chemical constituents soon renders any such theoretical calculation incompatible with what is found in real practice. Yet this is the assumption upon which "60,000 lamps of 20 candle-power" are to be paid for, giving a revenue of £93,750. In other words, we are to compare gas works having a capital of £9,375,000, and paying 10 per cent. thereon, capable of manufacturing and selling 750,000,000 cubic feet of gas at 2s. 6d. per 1,000, with works giving a vastly higher power in photometric value, but only having a capital of £220,000.

The calculations, therefore, to my mind as to revenue are absolutely preposterous, especially when I recollect that in the district in New York to be lighted by Edison, which is one mile square in the busiest part of the city, only the supply of 25,000 lamps is contemplated. The simple way to test the matter is that the public should be supplied with answers to the following questions:—

1st. What number of lamps are now employed in public lighting in the district at Nottingham?

2nd. What is the lineal extent of the mains and connections to be laid down?

3rd. What is the sum now paid privately for gas in the district?

As managing director of an electric light company, it will not be supposed that I am on the "gas side;" but as extravagant or misleading calculations, quite unintended, I feel sure, in the Nottingham undertaking case, only retard the "good time coming" when all shall take to electricity, I am desirous of bringing such to the sober grindstone of truth.—Yours, &c.,

EDW. H. WINFIELD.

THE SOCIETY OF TELEGRAPH ENGINEERS.—THE MICROPHONE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: I observe from your report of the last meeting of this society that I have caused your reporter to understand me to say that metal microphones were not "reversible," and did not act as receivers. On the contrary, I exhibited a metal microphone receiver which I had specially made to demonstrate that metal microphones are reversible as well as carbon ones, and that the reversibility is due to some general property of microphonic action, and not to any special property of carbon.

This property is, it appears to me, a repulsion which can be proved to exist between the microphone points when the "discharge" is going on between, and it acts, as I have elsewhere pointed out, like a reacting spring between the vibrating points.

The metal microphone receiver consisted of a pile of wire gauze squares in circuit with the line, and confined between a mica tympan and an electrode. The passage of the current through them set the tympan into audible vibration.

The metal microphone transmitter patented by Mr. Theiler is a simple hammer and anvil microphone of the kind employed before by Professor Hughes. Metal microphones of this kind are, I fear, not quite practical, owing to the "stiction," mentioned by Mr. Bidwell, and to wasting of the points.—Yours, &c.,

J. MUNRO.

2, Somerset-villas, West Croydon,
May 8, 1883.

THE YOUNGER DAYS OF GAS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: The following passage in reference to Winsor's Grand National Light and Heat Company is taken from *The Satirist* of 1808, Vol. I., p. 236. It was written, as you see, a long time ago, in the days when gas was young; but if for gas we read electricity it will serve very well to-day to express the hopes and aspirations of those of our brethren who are concerned in electric lighting and the transmission of power:

"Only think! light and heat to be conveyed, like water, through every street in London; and, they do say, that the liquid flame will be conducted, by means of submarine pipes, all the way from Pall Mall to the East and West Indies! supplying in its progress various light-houses, sea-lanthorns, &c., to be erected in divers parts of the Atlantic, Ethiopic, and Indian Oceans, which must prove of infinite service to our shipping in dark nights, and will enable our fleets to detect the enemy's squadrons, should they attempt to steal out of port after sunset. I am likewise assured that it will totally ruin the whole medical profession (another great national benefit) by superseding the necessity of physic, the gas being a sovereign remedy for asthmas, consumptions, and almost every other complaint."—Yours, &c.,

May 8, 1883. J. J. FAHIE.

THE VIENNA EXHIBITION.

TO THE EDITOR OF THE ELECTRICIAN.

SIR: In your issue of April 28, on the above subject you have been misinformed. Will you kindly take a convenient opportunity for stating that telephonic apparatus will not be exhibited by J. Coxeter and Son, but by—Yours, &c.

COXETER and NEHMER.

23 and 24, Grafton-street East, London, May 8, 1883.

ELECTRICAL MACHINES AND THE TRANSMISSION OF POWER.—We have received a long letter from M. Bandsept on this subject, replying to Mr. Gisbert Kapp's strictures on his previous letter to us. We regret that we cannot find room for it in our present issue, and are thus compelled to defer its publication to our next number.

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THE INSULITE SEALED BATTERY.

We herewith illustrate a battery which promises to be very useful. Ordinary batteries have certain disadvantages, which in this are overcome, such as loss of liquid by evaporation, which necessitates frequent supervision; the giving off of noxious fumes; fragility, and so on. An attempt has been

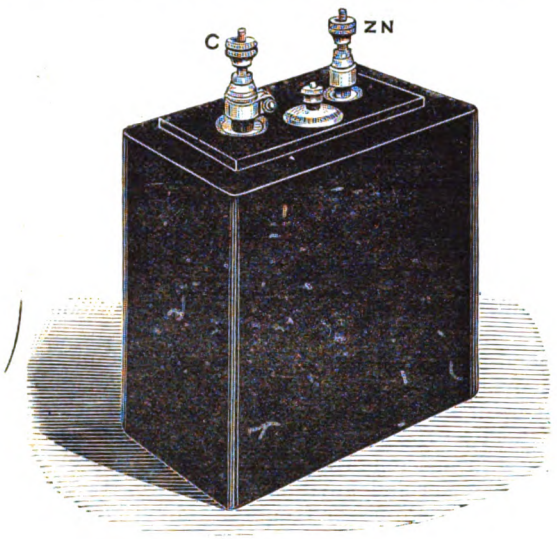

Fig. 1.—Insulite battery.

made to minimise these serious disadvantages in constructing this battery. It is made with an insulite case (Fig. 1), having a carefully and specially-prepared diaphragm, D, placed diagonally across, as shown in Fig. 2. The materials used in charging the cell are somewhat a modification of those in an ordinary Leclanché, viz., carbon surrounded by small lumps of carbon, and zinc, with a special excitant, harmless, non-corrosive, and non-poisonous. No gas is given off. An insulite lid is fitted upon the cell, and autogenously soldered on. Three holes are

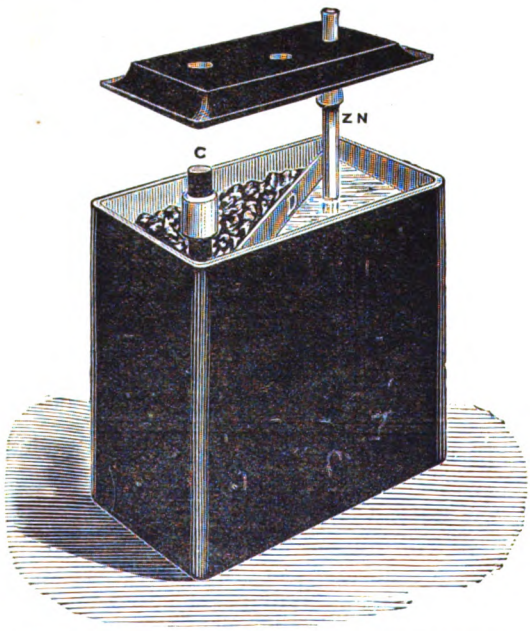

Fig. 2.—Insulite battery, showing internal arrangements.

left in the lid; through two of these the upper parts of the + and − elements pass, while the third communicates with a stopper and release valve. This valve is provided to allow for the slight variations of pressure in the contained air. The upper parts of the elements are fitted with small rubber cylinders, which by their expansion keep the holes in the lid both gas and liquid tight (see Fig. 2.) The terminals are split cylinders, nickel plated, gripping tightly the elements, which project some ½in. through the lid, and make good contact. The E.M.F. of the cells is said to be about 1·6 volt, with internal resistance of 1·5 ohm. They are made up singly, in couples, or in sets of three, contained in neat and elegant tin cases. With the release valve screwed tight the cells can be placed in any position, which conduces to their portability. It seems to us that the cells as supplied by the Insulite Company will meet a great want. They are sent out ready for use—no skilled labour is required to install them. The most ignorant of country bellhangers could hardly make a mistake in connecting the bells. On board ship they will be invaluable, as there is no evaporation, no slopping, no corrosion, and no attention required. A zinc rod is said to last about two years, and is then easily replaced. As the applications of electricity extend, and the testing of lightning rods, of electric light wires, as well as of telephone and telegraph wires, become ordinary work, a portable battery of this kind will be found very useful. Fig. 3 shows an insulite battery, with bell, bell-push, and wire attached for use in a sick room or elsewhere. The electro-magnets and hammer are all contained inside the dome of the bell, which is itself attached to an insulite block, and firmly held to the battery by the

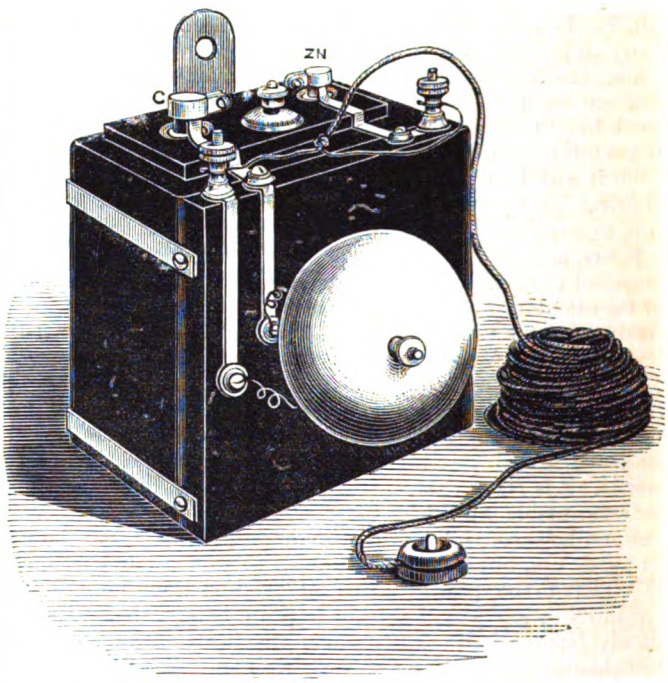

Fig. 3.—Insulite battery, with bell and wire attached.

strips of metal shown in the figure. The connections are so clearly illustrated as to speak for themselves.

MAGNETISM.

BY JOHN T. SPRAGUE.

(CONCLUDED FROM PAGE 595.)

30. The *magnetic field*, consisting of lines of force having *direction* and *intensity*, of necessity varies in force at its different parts; the *unit field* is that which exerts unit force on a magnetic pole; but, as in the mutual reaction of two poles, section 31, this magnet itself is a factor in the force, and $F = m \times H$, where m is the magnet and H the intensity of the field; distance does not enter into the formula because it is already one of the elements which define the intensity. H, which is always used as the symbol of magnetic intensity, is the field produced by the unit pole (Weber) at the distance of one centimetre, and more generally it is as $M \div D^2$, as the strength of the pole and inversely as the square of the distance. It is proposed to call the unit field intensity a Gauss.

31. The *strength of a pole* resembles the unit quantity of electricity, and a unit pole means *one which at one centimetre distance repels an equal similar pole with a force of one dyne*. It is related to the same formula as governs electric force, and $F = \frac{m \times m'}{D^2}$. In fact it is also called the unit of magnetic quantity, and it is proposed to call *it the weber*, a name

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which, highly proper in itself, will lead to great confusion, because it has been, until recently, the name of unit dynamic electric quantity and current. Its value is 10^8 C.-G.-S. units.

It should be understood that the pole of a magnet *is not a fixed point* in it; it is simply the focus on which the molecular forces combine; therefore this pole or focus will be changed in position by any cause which modifies the field of the magnet, such as the approach of a magnetic substance or another magnet.

32. *Magnetic Moment.*—In mechanics the "moment" of a force is its value under given circumstances, as of the force applied to a lever to move it around its fulcrum. A magnet is a lever, its centre the fulcrum, its poles the point at which the force is applied, and therefore the length of leverage. In such cases the action in opposite directions on the two ends of the lever, exerting an effort, not to move it in any direction bodily, but to turn it on its axis, is called a "couple," and the couple tending to turn any magnet placed at right angles to the pull of the field is $m\,l \times H$, where $m\,l$ is the *magnetic moment*, depending on m the strength of the pole, and l the length or distance between the poles. As a consequence of this, and also of the definition of magnetic intensity, if we have two bar magnets of equal dimensions and equal force, we double the "moment" of one by adding the other to it either end to end, as this gives $2\,l\,m$, or by placing them side by side, which gives $2\,m\,l$. In fact the *magnetic moment of any uniformly magnetised substance is proportional to its volume.*

The moments of magnets may be compared by their relative actions as regards another magnet. If we use the earth as this magnet (and do not need the high accuracy which would take into account the varying magnetic intensity of the earth itself) the moment of a bar magnet may be measured by suspending it by a fibre and counting the time of one oscillation or the number of oscillations in a given time, the relative moments are as the square of the number of oscillations, or inversely as the square of the time of one oscillation.

To obtain the moment in absolute measure a very short needle is freely suspended, so as to hang in the magnetic meridian over a zero line. The magnet is placed parallel to this line, at right angles to and in the plane of the needle, at such a distance that it produces a deflection of only a few degrees. Let θ be the angle of deflection, d the distance between the centres of the needles, H the horizontal component of the earth's magnetism, section 29, then $m\,l = H\,d^3 \tan\theta$.

Horseshoe magnets may be similarly measured if their ends are placed on the line which a bar would occupy, and the distance measured from the central point between them.

Among the examples quoted by Professor Everett, it is said that Gauss found the magnetic moment of a steel bar magnet weighing 1lb. (453·6 grammes) to be 10088 C-G-S. units, and that Kolrausch finds that the maximum permanent magnetisation retained by steel in very thin rods is such as to represent a capacity of nearly five times this. This gives according to these observers :—

Gauss, moment per gramme, 22·24. Intensity, 175 C.-G.-S.
Kolrausch ,, ,, 100·00 ,, 785 ,,

The magnetic moment of the earth is $·33092 \times R^3$ and the earth's radius R being $6·37 \times 10^8$ centimetres, this is 855×10^{23} C.-G.-S. units.

33. The *intensity of a magnet* may be considered as the relation of the force to the mass of matter it is charged on, and therefore varies as the ratio of the magnetic moment to the weight or volume of the magnet; thus, if one bar has a moment equal to that of another of double its weight, it is itself magnetised to twice the intensity. The C.-G.-S. unit of intensity is that of *a cubic centimetre having unit magnetic moment.* The earth's magnetic intensity is only ·0790 which is about ·0004555 of that of Gauss's pound magnet, section 32, and therefore 1 volume of highly magnetised steel has a capacity equal to 2,200 volumes of the earth's mass regarded as a uniformly magnetised body.

34. *Magnetic capacity* would be a suitable name for the maximum intensity which could be imparted to unit volume of any substance. Professor Rowland gives the value in C.-G.-S. units :—

Iron and steel at 12° C.	= 1390;	at 220° C.	1360.
Nickel	,, 494;	,,	380.
Cobalt	,, 800?		

But this is a subject requiring examination, because it is very certain that different qualities of iron and steel possess very different capacities as to *reception* of the magnetism imparted by a given or maximum current, and as to the permanent magnetic force it can retain, section 35. Different authorities give values ranging from 400 to 1000 for steel.

35. *Saturation* implies that a magnet is charged to the utmost the capacity of its materials will admit. Under the influence of an electric current, the magnetism will at first grow in the ratio of the current, but after a time the growth of the current produces a diminishing growth of magnetism, till at length a limit is reached at which no additional current will increase the magnetism. Steel reaches this point sooner than soft iron. But when the magnetising force is suspended, the magnetism is lost to some extent, till an intensity is reached which is tolerably permanent. Iron loses the magnetism almost entirely, though a small "residual magnetism" is always retained. The softer and purer the iron the more freely it absorbs and the more completely it gives up the force.

36. *Coercive force* is a name given to this property of resisting and retaining magnetism. If steel were the only substance possessing it we might attribute it to some insulating or polar action due to the carbon; but as nickel and cobalt both possess it as pure metals, all we can say is that we do not know what imparts the quality.

37. *Consequent poles* are similar poles opposed in the bar of metal as (N——SS——N) where we have the apparent anomaly of a magnet with two north poles: such magnets have uses and are largely used in dynamo machines; but consequent poles destroy the value of ordinary magnets. If a piece of soft iron is applied to the N end of a bar magnet, it is attracted because polarity is induced in it; it becomes itself a magnet with its S end in contact with the magnet. If, now, a second bar magnet is applied with its S end to the other end of the iron, the action is increased, the iron held with double force; but if the N end of this second bar be applied, the two actions neutralise each other, and the iron, though in contact with two magnets, will have only a slight attraction exerted upon it. In this case the armature has consequent poles formed in it and the opposing fields neutralise each other. The same effect is produced if a N pole approaches the end of a piece of iron hanging from a N pole; the iron may fall off. If a S pole were approached, instead of weakening the attraction of the magnet and tending to draw away the iron, the attractive force would be increased.

38. *Auroras.*—These are closely connected with the earth's magnetism, although the exact relation is not known. They are not unfrequently attributed to *electric* discharges, similar to those effected in vacuum tubes, occurring in the upper strata of the air. But the aurora is a general, not a local phenomenon, though it may be more strongly displayed at particular parts. There is ample evidence that auroras are manifested in both north and south polar regions at the same time, while we have no reason to suppose that these have opposite electric charges or conditions, and have very much evidence that electric currents circulate around the earth much as though the earth were an electro-magnet; the reverse action is, however, possible, and the currents might be due to changes in the magnetism. It seems more probable that the aurora is really an illumination of the lines of magnetic force; at all events, the auroral corona always forms around the position of the magnetic pole, and its lines correspond to those of the magnetic field; there appears also to be some connection between the aurora and *parhelia* or mock suns, which are due to a peculiar arrangement of ice particles in the upper air; this renders it probable that the play of light and colour and the shifting streamers of the aurora are due to the magnetic lines of force affecting the constantly varying strata of moisture floating in the air.

Professor Lendstrœm, of Helsingfors, has, it is said, recently produced natural auroras by artificial means. He raised a number of points on the summit of two hills, one of them 3,600ft. high, in 67° N. lat., connecting these points to earth at the foot of the hill; an aurora was formed rising 300ft. in the air, and exhibiting the true auroral spectrum. This result, due to development of lines of atmospheric electric discharge, is probable, because the aurora does strongly resemble some forms of electric discharge; but this would not diminish the probability that the natural aurora is a luminous effect of magnetism rather than of true electric discharge.

39. *Magnetic Storms.*—These are the constant accompaniments of the aurora, but often occur when there is no visible aurora. They have been observed to accompany changes in the sun, sudden outbursts of the hydrogen prominences and development of sun-spots. No doubt they influence health and weather, but they have no necessary or obvious relation to these. They consist in the development of strong but fluctuating currents in the earth, which frequently rise to a force of 200 Daniell cells and occasionally to 2,000. The direction is usually from east to west, as though the positive current followed the sun. Telegraph lines running east or west become useless, except by connecting two together to form a complete circuit independent of the earth; but lines running north and south are comparatively unaffected.

On 17th and 18th November, 1882, a severe magnetic storm affected the whole earth, and suspended telegraphic communication in great degree. It was accompanied with a brilliant aurora. There were also heavy snowstorms in many places, and at the

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same period there were several large sun-spots forming in the sun. Paragraphs went the round of the papers saying that "by means of the storm alone, electric lights requiring eight horse-power were kept burning some time." This, however, resolved itself into the fact that an eight-candle Edison lamp had been illuminated. During this storm the earth's magnetism underwent rapid fluctuations, and the declination varied 1° 18′, and the dip half a degree. Simultaneous changes were observed in Europe, America, and Japan.

40. *Diamagnetism.*—By means of electrical currents and helices, magnetic effects can be developed in all substances, and Faraday and others, by means of very powerful magnets, have proved that magnetic actions do thus occur, modified by the nature of the substances and their molecular arrangement, which lead to a classification of substances as magnetic and diamagnetic.

The first class, when interposed between the poles of a magnet, place themselves with their longer axis in the line joining the poles; the latter arrange themselves across that line. There has been a tendency among some philosophers to attribute this to a force distinct from magnetism, but there seems no sufficient reason for it, as the properties of the magnetic field will explain the facts; it would seem more probable that the diamagnetic substances are those in which the faculty of assuming the magnetic condition is feebler than in air, and that therefore the molecules of air form the field more readily than those of, say, bismuth, and consequently move these latter into the position in which they take up the least portion of the lines of force; thus a tube containing a weak iron solution will be magnetic in air, but suspended in a vessel containing a stronger solution of iron it acts as a diamagnetic substance.

41. Before leaving the subject of magnetism, it will be well to point out the error of the common conception of magnets as inexhaustible sources of force. It is this misconception which has led so many to waste their time in trying to devise perpetual motion machines, of which magnetism was to supply the motive power. It has also given rise to many questions as to how it is that a magnet can impart force to any number of other magnets without itself parting with any force.

Magnets, like springs, can only exert the power which has been put into them; *they have no force of their own.* In the act of magnetising, whether by magnets or by electricity, a certain amount of energy is charged upon the molecules just as it would if each of the molecules in Fig. 4 were a spring which was wound up in the act of magnetising. When the magnet exerts any force, *it parts with that force;* it is to that extent exhausted, and the energy it parts with is distributed over the new "field," or in the armature, &c., which has been moved. If the armature is a mass of iron as large and heavy as the magnet can hold, the magnet is exhausted; it will no longer affect external magnets, &c., or but very slightly. Before the magnet can exert any further force the requisite energy must be restored to its molecules. This is done by removing the armature, which requires an exertion of force equal to that exerted by the magnet in attracting it.

The distinction is simple, but important; the common idea regards the removal of the armature as an exertion of force against the power of the magnet, and in some sense this is so. But the real action is the restoring to the magnet the force which it has given up to its armature, which is effected by the molecules themselves so long as they retain the magnetic condition.

So in the act of magnetising, it is not the magnet which gives the force, but the energy expended in the act, just as in cutting a piece of iron with a steel chisel it is not a force in the chisel which does the work. The magnet and the chisel have each certain molecular properties which enable external energy to produce the desired effect; in the one case of effecting a molecular arrangement in the steel bar; in the other of destroying the molecular arrangement and cohesion of a piece of iron.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY (LIMITED).

The nineteenth half-yearly general meeting of this Company was held at the Cannon-street Hotel on the 4th of May, 1883, under the presidency of the vice-chairman, Sir James Anderson.

The SECRETARY (Mr. Richard Collett) read the notice convening the meeting, and the minutes of the last general meeting, which were confirmed by the present meeting. The report of the directors, an abstract of which has appeared in *The Electrician*, was taken as read.

The CHAIRMAN said he was sure the shareholders would join with the directors and himself in regretting the absence, through illness, of the noble chairman of the Company (Viscount Monck). Everything concerning the Company was going on well, and there was very little to draw their attention to in the accounts. The increase in the receipts over the corresponding six months of the previous year had been £1,700. There had been an increase in the London expenses of £230, but at the stations they had shown a decrease of £23. The increase in the London expenses was owing to their having had to paint their office, and to renew their furniture. He was happy to say that their reserve fund now amounted to about £360,000. He admitted that this was a meagre statement to make to them, but there was really nothing to say to them with respect to the half-yearly report before them. Probably, however, some of them would know that the Company was now face to face with an opposition line which had been laid down along the West Coast of South America. They were not yet suffering from this opposition, though the other company was taking traffic at lower rates, but no doubt they would have to face a reduction of tariff before long. Still, his own idea was that the increase in the traffic would in a short time recoup the loss of revenue, as they had a very high tariff—the highest tariff, he believed, of any company in the world. They had had their monopoly for ten years, during which they had developed a trade gradually, and they found that they had always had a growing trade, which, too, was capable of much greater development. They had formed a good reserve fund, and they had also duplicated one of their sections. Some objection had been made by one shareholder to their carrying the interest of the reserve fund to that fund. The Company's solicitor, however, on the matter being referred to him, had informed them that it was quite within their power to do so, and that they ought to do so; and that it was customary among all the cable companies to do so. The policy of this board—and it had been the same at all other cable boards with which he was associated—had been to build up the reserve fund—to, above all things, have the property intact, or to have that at the bank which would enable them to be in that position. That policy had been acted on from the beginning of the Company by the directors, and they had been supported by the shareholders uniformly in adding substantial additions to the reserve fund. It had always been their purpose to add the interest of the reserve money to the reserve fund, as well as the £50,000 a year, which the shareholders sanctioned some few years ago. He did not think that any one who valued the property and knew anything about the risks of submarine cable property laid in very deep water would object to their keeping up the reserve fund so long as a fair dividend was paid. He then moved the adoption of the report and accounts.

Mr. FREDERICK YOULE briefly expressed his pleasure in seconding the resolution.

Mr. LAW inquired whether it had been necessary to take money from the reserve fund to pay for the duplication of the cable, and if any security which had been sold had realised a profit.

The CHAIRMAN replied that they had sold none of the securities. They had managed with current money, and by borrowing a small sum, to do the work. They hoped they would go on in the same way, and duplicate the whole of their cable. The cost had been charged to the reserve fund. He then put the motion, which was carried unanimously.

Mr. LAW thought the directors deserved very great credit for the way in which they had conducted the affairs of the Company, and therefore moved a vote of thanks to them.

Mr. CRANEY seconded the motion, which was carried unanimously.

The CHAIRMAN having acknowledged the vote, the meeting separated.

THE ELECTRIC LIGHTING, CONTRACT, AND MAINTENANCE COMPANY (LIMITED).

The second ordinary general meeting of this Company was held at the Cannon-street Hotel, on the 9th inst., under the presidency of Mr. Martin R. Smith.

The CHAIRMAN reminded them that at the statutory meeting last July it was arranged, with the full consent of the shareholders, that no decision should be come to with respect to the policy of the Company until the expiration of six months, in order that they might see whether the course of events would produce any alteration in their prospects, and whether their affairs, which then looked so unpromising, would improve in the interval. He was sorry to say that that had not been the case. They proposed now that the Company should be liquidated. They had, in fact, to confess a failure, and he would inform them of the reasons which had led them to suggest the liquidation of their affairs as being the best course they could adopt. Before doing so, however, he should like to congratulate them on the position of the Company, for which the directors took some little credit. With the exception of a very small sum—liabilities for rent and salaries—their capital was practically intact. They were connected with no system of lighting or the purchase of any patents, and they were absolutely free and independent. The plain truth of the matter was that they had done no business. They had found that it was impossible to procure for themselves to their own satisfaction a proof of profit in any way commensurate with the risks they would have had to undertake. When he said that they had done no business he did not wish them to understand that they had no opportunities of doing business. They had, in fact, had numerous opportunities. They had had proposals and solicitations which would have absorbed their paid-up capital over and over again, but they had all presented considerable risk and small profit. As to the original formation of the Company in March, 1882, when they were established, the electric light was considerably embarrassed for want of capital. Plenty of business of a sort was then offering, the business mainly consisting of offers to take the light on trial at the risk of the patentees supplying it. Great ignorance then prevailed as to the cost of the electric light. The most sanguine expectations were held, and the cost of electric lighting was boldly announced to be considerably below that of gas. If a half, or even a quarter, of that which was then so publicly announced had been borne out by subsequent facts the Company would now be in a different position. The result of this was the electric light mania of last year. They might all remember that dividends of 10, 20, and even 30 per cent. were boldly pronounced possible. Every day fresh systems were started, and new companies were brought

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out. The first cloud appeared on the horizon in the action of the Legislature with respect to the electric light. There was no doubt that the Legislature were perfectly right in trying, as regarded the new light, to avoid the dangers which they had fallen into with respect to gas. They determined not to fall into the same trap twice, and a Bill was brought into Parliament hampering the electric light most seriously. It imposed the most vexatious restrictions and regulations. One of them was that, if the light was successful and proved to the satisfaction of the authorities, they had the option of taking it over at the expiration of 14 years—he believed the period had been since extended to 20 years. If the light was a success the authorities could take it over, but if it were unsuccessful the company were to bear the loss. Had such legislation been laid down as to gas, he believed they would still have been using oil. The Bill passed last year had done more than anything else to prevent the electric light from competing with gas. The result of all the companies starting was excessive competition. He knew of one instance where the electric light was supplied free of cost, and he knew several other instances where it was supplied at a price which could not possibly pay. The universal offer was the electric light at a price equal to that charged for gas. He did not say that the public were to blame if they took the companies at their word. He knew that consumers fairly laughed at them if they attempted to suggest any excess in the price of the electric light over that charged for gas. He maintained that the electric light could not be supplied at the same price as gas—at least he said that no system, at any rate of incandescent lighting, with which they were acquainted at the present moment could show that it was working at a profit commensurate with the risk they were asked to run. He must say that on the previous day he had been informed that an electric lighting company had made up their accounts, and had realised a profit. He was very glad to hear it, and perhaps knowing that, he ought not to speak so sweepingly; but he would say that, acting on the lines of their prospectus, they had not seen their way to compete with gas. He could quite conceive that a well-managed company, with its own works, manufacturing its own plant, not overburdened with money expended on the purchase of patents, might pay their way, and keep going; but more than that he would not allow. Of course they would understand these remarks only referred to the present. He supposed he was not far wrong when he said that the whole scientific mind of the world was pretty well concentrated on the subject of the electric light, and undoubtedly events moved fast, and a thing that to-day was commercially and scientifically impossible, might to-morrow or next month be an accomplished fact; but they had to deal with matters as they now stood. As they stood at that moment the directors did not see how they could employ the money of the shareholders in electric lighting with any prospect of returning to them a good dividend commensurate with the risks they must inevitably run. He would not go into figures, but he did not think it would be difficult to prove to them that any diminution of the present cost of installation was not very probable, as only two-fifths of the expenditure on installations could be materially affected by scientific discoveries. He had also to call to their mind the very low price of gas in this country. That put the electric light companies at a tremendous disadvantage. He could understand that the electric light could be produced at a very considerable profit at New York and on the Continent, where gas was two or three times the price charged in this country. They must remember that gas companies would not be idle, and that the moment they felt themselves seriously pressed by the electric light companies a great reduction in the cost of gas and great improvements in it would inevitably be seen. He thought they had a proof of that in the improved street lighting which they now saw. Until science had discovered a means of producing the electric light at a price at which it could compete with gas, he for one must say that electric lighting was somewhat hazardous. Science, it was true, might at any moment solve these difficulties. But what they had now to consider was whether, in the absence of any immediate prospect of remunerative business, the directors would be justified in asking the shareholders to postpone the liquidation of the Company? He then referred to the statement of receipts and disbursements, and warmly eulogised the services which Messrs. Lee and Young, the managing directors, had rendered to the Company. It was due to those gentlemen that the Company had not lost any of its capital, and he should propose that they receive 500gs. Of course, the directors were greatly disappointed in having to come before the shareholders with such a story, but they believed in their Company, and had proved their belief by holding about one-fifth of the capital. They still believed in the principles upon which it was founded, and also in the future of electric lighting, but the fact of the matter was they had come into the world a little too soon. Had they begun now instead of fifteen months ago they would have been in a very much more satisfactory position, as he believed that the time was coming when the electric light was going to make a fresh departure. That morning they had received a proposal from a gentleman which he believed was one which would show a very fair return for every farthing of the capital of the Company. The only way by which such a proposal could be fully considered would be by some gentleman proposing the adjournment of the meeting for a month. It came from one of the largest and most respectable companies in the City of London, and he conceived himself that it might lead to very satisfactory business. He concluded by moving the adoption of the statement of receipts and disbursements.

Mr. WHITLEY (shareholder) seconded the motion.

The CHAIRMAN, in reply to a question, stated that he could not mention the terms of the proposal to which he had referred. Having replied to a few other questions, he put the motion, which was carried, as was also the suggestion of the chairman, which was seconded by Mr. Tagart, according 500 guineas to Messrs. Lee and Young.

An extraordinary general meeting was then held, at which

The CHAIRMAN moved, and Mr. YOUNG seconded, a resolution for the voluntary winding up of the Company, the chairman, in reply to a question, stated that the affairs of the Company were in such a position that they would be able to wind up in the shortest time permissible by law. They would be able to return a large portion of the capital immediately.

A vote of thanks to the chairman and directors terminated the proceedings.

GREAT NORTHERN TELEGRAPH COMPANY OF COPENHAGEN.

The annual general meeting of this Company was held at Copenhagen on the 28th April, when F. Zahle, Esq., presided.

The chairman, C. F. TIETGEN, Esq., in reporting upon the condition of the company's cables, observed that with regard to those in Europe, the past year had been the most favourable that the Company had experienced. One of the short cables between Finland and the Aland Islands had been interrupted in the month of January, but fortunately the Gulf of Bothnia, which is generally closed at that time of the year, was free from ice, and the Company had, therefore, been able to effect the repairs within eleven days. With this exception, no interruption had occurred, and even the Danish-French cable, which had in former years given much trouble, had not suffered during the year, and the valuable traffic carried by that cable had thus not been disturbed. It had been different with regard to the cables in the far East, where the interruptions from the usual causes, say anchors and fishing, had been numerous. The cable between Wladiwostock and Nagasaki had been interrupted once, for twenty-three days; the Nagasaki-Shanghai cable six times, for thirty days in all; and the cable between Shanghai and Hong Kong eight times, for sixty-two days. These interruptions might almost be called epidemic, as they nearly all occurred in the early part of the year, whilst during the last six months of the year there had not been a single repair to effect. Notwithstanding these interruptions there had been an increase in the traffic receipts, mainly owing to the successful working of the European cables.

The company's European cable steamer, the "H. C. Orsted," had not been idle, as she had been employed in repairing cables for other parties. Thus, she had in the month of May repaired the Direct Spanish Telegraph Company's cable near Bilbao, and in November the Sound cable, belonging to the Dutch Government. Notwithstanding the amount of work there had been for the company's cable steamer in the far East, the "Store Nordiske," she had also been able to undertake outside work, and had repaired the cable in the Tsugar Strait, belonging to the Japanese Government. The receipts derived from this extra work had considerably contributed to diminish the ordinary expenses of the two ships.

It was to be hoped that the proposed measures for the protection of cable property, signed in November last at Paris by delegates from Governments of all parts of the world, would have the desired effect of diminishing the injury which was constantly being done to cables by anchors and fishing operations. It had been adopted in principle that all damage done wilfully, or in consequence of culpable negligence, should be punishable by fine or imprisonment, or both. It was to be regretted that it had been impossible to get inserted into this protection convention a clause with regard to the actual control of the construction and condition of the different fishing apparatus (amongst which was that cable scourge, the trawl, from which the company's Danish-French cable had suffered so much); but, as it was, a good beginning had been made, as a basis for international legislation had been established, which would no doubt be further developed in the future.

But with all this, the best, the safest mode of ensuring regularity in the service of telegraph routes, was undoubtedly duplication. This not only increased speed under ordinary circumstances, but prevented cessation of work during a breakage. The excellent results of this duplication, and he might with regard to some routes say triplication, as introduced in the company's European system, had for some time past had the full attention of the board as regarding the company's lines in the far East, for which it had hitherto been impossible to provide such a reserve. The Company had, however, during the past year succeeded in obtaining the desired conditions for carrying out such duplication in the far East. It being in the interest of the Japanese Government, and also in that of the Russian Government, on account of their land line system, that this duplication should be carried out, the Company had been enabled to make satisfactory arrangements with both Governments. The Japanese Government had given the Company the exclusive right to connect Japan by telegraph cables with the Continent of Asia and the adjacent islands for the next twenty years, which term may subsequently be extended. The Russian Government, following the example of Sweden and Norway, had likewise extended all the concessions of the Company for their connections with the Russian coasts up to the year 1912. These preliminaries having all been arranged, the Company had made a contract with the Telegraph Construction and Maintenance Company, in London, for the making and laying of the cables from Wladiwostock to Nagasaki, and from Nagasaki to Shanghai. The manufacture of the same had now been nearly completed, and the cables were expected to be laid and in working order in August and September this year. With reference to the cable between Shanghai and Hong Kong, the duplication of which was of as great importance to the Company as that of the other sections, the Company had, always with a view to the consent of the Chinese Government, made arrangements with the Eastern Extension Telegraph Company to the effect that the latter should undertake that part of the duplication. That arrangement was based upon the terms of previous agreements existing between the two companies, and the terms were such that this Company would derive the same benefit as if they had themselves undertaken the duplication. In order to meet the expense of the new lines of the Company, the directors being duly authorised, had, on the 1st of March, issued £300,000 five per cent. obligations, redeemable in not exceeding thirty years. The obligations had been offered to the shareholders and the general public by the Private Bank of Copenhagen, and by Messrs. C. J. Hambro and Son, of London, where nearly the whole amount had been placed. It was a satisfactory proof of the growing confidence of the shareholders in the Company's undertakings that the raising of so considerable a loan had in no wise affected the price of the shares, nor was there any reason why that should have been so, as the interest and redemption would only absorb £20,000 per annum, an amount which might fairly be expected to be earned by an increase of traffic consequent upon the duplication. But even if this expectation should not be realised, which was hardly probable, the amount would easily be covered out of the large sums which had hitherto every year been set aside for the reserve fund, which fund would in future, after the establishment of the duplication, not require such large augmentations.

After referring to the different items of the balance sheet, the chairman

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closed his remarks by assuring the shareholders of the directors' continued confidence in the future of the Company, a confidence they had shown by proposing an increase in the dividend, which would thus be 8 per cent. for the past year. Without discussion, the report was then unanimously adopted, the accounts were passed, and discharge given to the board of directors. The retiring director, C. A. Broberg, Esq., was re-elected. The shareholders' auditors, His Excellency Admiral Bille and A. Berner, Esq., were also re-elected.

THE HAMMOND ELECTRIC LIGHT AND POWER SUPPLY COMPANY (LIMITED).

The second ordinary general meeting of this Company was held at the Cannon-street Hotel, on the 9th instant, under the presidency of Sir C. L. Young, Bart.

Mr. PHILIP A. LATHAM (the secretary) having read the notice convening the meeting,

The CHAIRMAN said that considering that the business in which they were engaged was altogether new, and considering the great difficulties they had had to contend against in the past year - difficulties and anxieties which were inseparable from the starting of an entirely new undertaking —he trusted they would regard the report as not wholly unsatisfactory. They were able to pay a dividend of 5 per cent., to write off £5,000 from the goodwill and concessions account, to place £3,000 to the reserve fund, and to carry forward to next account £1,088. With regard to their losses, or, perhaps, he should say, their failures of profit in the matter of the Lane-Fox license, when the prospectus of the Company was originally issued, care was taken that the licences should clearly understand that the Company had to offer precisely what Mr. Hammond had acquired from the Brush Company, and therefore the language of the prospectus was rigidly limited to the language of the Hammond concessions, but at the same time the Board, or the majority of them, were under the impression that the Company possessed the exclusive use of the Lane-Fox lamp. The question of practical ownership had never arisen. Consequently, when the then secretary drew up a tariff of prices, there did not seem to the Board anything inaccurate in the words "sole concession for the Brush and Lane-Fox patents." Certain parties purchased concessions from the Company, and the transfers of the licenses were made out in due form, copied from the licenses which they held from the Brush Company, and they were submitted to and approved by the solicitor of the Brush Company. Then the sub-companies came out with prospectuses, with which the Hammond Company had nothing to do, and those prospectuses intimated that the sub-companies possessed the sole and exclusive right to the Lane-Fox patents. On the faith of those prospectuses those companies had their capital subscribed. Then came the collapse of the great speculation in electric light shares, and people began to think how to get out of them. A letter then appeared in the public press stating that the Lane-Fox patent was not held exclusively by the Brush Company or its sub-companies, but that the British Company had the same rights to use the lamp under another name. Then this Company's licencees turned on them, and accused them with selling what they did not possess, and threatened actions for the recovery of the money paid to the Company and the damage sustained. The position was this: They took the advice of eminent counsel, and they were advised that, while they had a strong defence to the threatened actions, the far more prudent course for them to take in the interests of the shareholders would be not to enter into protracted and costly litigation with the sub-companies, the ultimate result of which might be the crippling of the Company's resources and the great detriment of their proper business. Therefore, after long and most anxious consideration, they resolved to take the advice of their counsel—repay the money they had received, and look to the Brush Company to recoup them for the loss they had sustained from the reticence of that company on this important point. He wished it to be understood that he was making no personal charge. A suit was pending between the Company and the Brush Company, who were suing this Company for the balance alleged to be owing on a very large order which the Hammond Company gave them, but which they had withheld in the belief that they had an ample set-off against the claim made on them by the Brush Company. Their claim against that company was far heavier than the Brush Company's claim against them. There were two other suits of a similar nature against the Company which they had not compromised in any way. Parties had paid a certain amount to them in order to secure an option, but those parties had brought out no prospectus or proceeded in any way, and the Company felt that in these circumstances they were justified in keeping the money so paid to them. They had had great obstacles to contend with—he did not allude so much to individual prejudices as to that which was always a difficulty to contend with—the man in possession, the gas companies, who had such a tremendous monopoly. He maintained that if electric lighting had done nothing more it had conferred a great public benefit by compelling the gas companies to light the streets better. Spending a great deal of money, however, to induce other people to do their duty was not usually a commercial success, and what they had to do was to go on until they attained that measure of success to which they knew they were entitled, and which they felt sure was not far off. The Electric Lighting Act, which at first seemed prejudicial to them, was really a great step in their favour, for it had given parliamentary recognition to a great fact, and, though only tentative, it legalised a position which before was uncertain. They could not complain of the forms and processes which had to be gone through before they got in such a position as the great gas companies; and it was for them to show that they could serve the public better. It had been said that no public electric light contract had shown a profit to the contractor. He was not prepared to admit the accuracy of the statement, but he should like to know what gas company could show a profit from its street lamps if it had not the privilege of the private lighting. With their new Ferranti, which could run 5,000 lights, they could, he maintained, serve a district better than a gas company, and show a profit on the business. Gas was carefully excluded from all the best drawing and dining rooms in favour of oil lamps, nor was gas found in any room in Pall-mall. Was it to be supposed that these people would not, if it were possible, adopt the incandescent system of electric lighting? To light such a district, however, there were great difficulties, and vestries, committees, and boards of works had to be tackled before they could move an inch. Well, they would all have to be tackled. It was a large stone that they had to start rolling, but once started, they would reap the reward of their patience. Meantime, they must content themselves with such progress as they could make privately. In certain quarters they had met with considerable success, and those who had adopted the electric light in their business were not likely to abandon it. He then referred to the progress of the electric light in America, and remarked that when London had a municipality worthy of its imperial position, the citizens would not be the victims of monopolies, but would be in a position to avail themselves of any improvement which science could give us. He then referred to the position of Mr. Hammond, and stated that it was provided in the Articles of Association that that gentleman should undertake the position of managing director without any salary. It was not, however, contemplated at the time that he should give the Company his exclusive services, whereas, as a matter of fact, he had had to give his whole time, thought, and energies to the affairs of the Company. Such a state of things was unfair to all parties, and the directors, therefore, proposed to make an alteration in Mr. Hammond's agreement with the Company, so as to retain his exclusive services. Mr. Hammond had agreed to devote himself exclusively to the interests of the Company for an annual payment of £1,000, and they thought they would be only properly recognising his services in the past year by giving £500. He concluded by moving the adoption of the report and accounts, and the payment of a dividend of 5 per cent.

The MANAGING DIRECTOR (Mr. Robert Hammond), in seconding the motion, stated that among the shareholders he felt that he was addressing an audience perfectly at one with him as to the ultimate future of the business. Let them go back a year, and see the task which had been set before the Company. There were many who seemed to think that the only purpose for which the Company was started, was to keep as much of its capital as possible at the bankers, to save at every turn, and to incur no expenditure in pushing its business. A year ago what was the position of the electric lighting industry. They had just seen the close of the Crystal Palace exhibition. It had been proved most conclusively that the electric light was going to become an immense factor in the lighting of the future; that, in fact, they were in a new epoch —as new as that which greeted railway men when they started the first railway. Some of the companies, and the Hammond Company in particular, impressed with this conviction, immediately prepared for the work which was in future, and they were determined to arrive at such a position that they should get their fair share of the work. In the past year the Company had had this one object before it—to prepare itself for the immense industry coming on, and had striven to make its name well known and respected in every part of England, and to have its name connected with work which would not shame the electric light industry. They had got around them a set of men who could be perfectly trusted to undertake any work given to them. All over England he was constantly meeting men of leading position who were gaining confidence that when he gave them figures they could trust to them. In August, therefore, when the Board of Trade orders were given out, he believed they would find themselves not only able to do the work, but with such a name established, that they would get a fair proportion of the work. At Leeds the chairman of the gas committee had told him that they were convinced of the advantages of the electric light, that did not injure health or property by sulphuretted hydrogen, that a light which in every way was desirable to make the home the happiest and most comfortable spot in the world was the light they intended to have in Leeds, and they assured him (Mr. Hammond) that though they had £1,000,000 invested in gas, that would not deter them from putting down the electric light system on a large scale. This feeling was endorsed in almost every part of England. Confidence had, however, been shaken by the large amount of bad work which had been done in connection with the electric light, and in the past few weeks he had been confining himself almost exclusively to inspiring confidence. The Hammond Company had made itself ready for what was to come, and it could give the most accurate information as to the electric light and its cost. They started as an offspring of the Brush Company, and they had a certain number of counties allotted to them in the North of England in which to work under the banner of the Brush Company. It would have been expected in the circumstances surrounding this Company that it would have had every assistance and advice from the Brush Company, but that expectation had not been realised, and it was very soon seen to be evident that they could not continue under the banner of the Brush Company. The Crystal Palace exhibition was, to a certain extent, disastrous to the interests of the Brush Company. He believed it laid the basis for a future, but it showed people that the Brush was not the only system, and it had all the more reason to put down its prices, and the business should never have been allowed to pass them. Then the Brush Company did what was almost suicidal in the interests of this Company by declaring a dividend of 100 per cent.—not a return of capital but a dividend of 100 per cent. People informed him when he went round that they would have nothing to do with a company which paid such a dividend. He had found it impossible, in face of such a state of things, to persuade people that the machinery was to be had at the lowest possible prices. The Hammond Company saw at an early stage that the future of electric lighting depended on the incandescent system, and they urged the Brush Company to produce machinery that would run 5,000 or 10,000 lights. They could not, when they endeavoured to get a 500-light machine, obtain it, and they were told to add together three machines—two of 200 and one of 100 lights, which would have made £1,800 for a Brush machine to run simply 500 lights. They saw that, linked with the Brush Company and crippled up in the north of England, their prospect was not a tempting one, and they therefore determined to act independently and to see if they could not obtain machinery of their own and to have the whole field to themselves instead of a few counties. At that time a machine was announced which had been invented and patented by a young fellow named Ferranti, who was working at Messrs. Siemens, who, however, found, to his great disappointment, that in the vital part of the machine, the armature, he had been preceded by so great an authority as Sir Wm. Thomson. A fusion of interests at once took place between Mr. Ferranti and Sir Wm. Thomson, who thus acted most nobly. Then arose the question—where was the capital to come from to set up the works necessary in connection with the machine? Finally, he himself paid a deposit of £5,000, and bound himself personally to find the £60,000 required, on the condition that the Hammond Company should become sole agents of the Ferranti machine to

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the extent of the English patents. He had been called upon to find £25,000 out of the £60,000, but this responsibility had been shared by one of the largest shareholders in the Company. If the Hammond Company wished to take this stake it could do so. The idea of making a machine to run 5,000 lights was seen to be possible with this machine. He had been to Leeds, and had been delighted to see the progress which was being made by the manufacturers with the machine. When the Ferranti machine ran and produced these 5,000 lights, it would cause an immense sensation throughout the whole electric light world. No great work would be done until the provisional orders were out in August, and they felt that they had the year well in hand. What they had to aim at was a machine which would run 50,000 lights, as the object must be to produce the electric light on as large a scale as gas. They were prepared to put up plant to supply 40,000 lights at 2s. 6d. per 1,000 cubic feet, speaking in gas parlance, and where coals were cheap he calculated that it might be done at 1s. 7d. They had had to do with an incandescent lamp which had caused grievous disappointment, and for £2,878 they had secured Wright and Mackie's patents. They had been negotiating for the purchase of an accumulator, and if one was offered to them fulfilling conditions making it the best in the world they would have it. They had had great legal difficulties to contend with, in connection with which they had had the able assistance of Mr. Ince.

Mr. REYNOLDS referred to the progress of the two sub-companies of the Hammond Company at Eastbourne and Hastings, with which he was connected.

Mr. WOOD supported the action of the Board, and expressed his satisfaction with the dividend of 5 per cent.

The motion was adopted, and the auditors were afterwards reappointed.

Mr. REYNOLDS then suggested that a small committee should be appointed to act with the Board in order, if possible, to bring the suit between the Company and the Brush Company to a satisfactory conclusion without [illegible] before a court of law.

The [illegible] assented to the suggestion. The proceedings terminated in the usual manner.

MAXIM-WESTON ELECTRIC COMPANY (LIMITED).

The adjourned general meeting of this Company was held in the Cannon-street Hotel, London, on the 4th inst., under the presidency of Admiral Sir E. A. Inglefield, C.B., F.R.S.

The CHAIRMAN reminded the meeting that they left off on the former occasion by not passing the accounts, which the directors considered as a vote of want of confidence. They then proceeded to the question of electing the two directors who retired by rotation. The two directors were Mr. John Scarlett Campbell and Mr. Hugh Watt. But it seemed, as the shareholders had not sent in any names of gentlemen to take the places of Messrs. Campbell and Watt, that those gentlemen had been virtually re-elected, or remained directors for another year. That they were advised was the legal state of the case. But to show that, as a Board, they had no desire to remain as managers of the affairs of the Company without the shareholders' confidence, they had passed a Board resolution, by which they desired to offer their resignation. It was necessary that the shareholders should elect another Board, whose names must be sent in seven days beforehand. For that reason it was proposed to dissolve this meeting. In the meantime the interests of the Company would not in any way be neglected, as the present directors retained their seats. They would remain in office and do their best for the Company till other gentlemen had been appointed. The only difficulty would be the question of the raising of the new capital. That was all he had to say. The question of the directors was settled; as they would see, by law, but notwithstanding that, they, *en masse*, gave their resignation to the shareholders. It would be necessary to elect an auditor in place of Mr. Dever, who offered himself for re-election.

Mr. LEE proposed, and Mr. ROSSEN seconded, the re-election of Mr. Dever.

A SHAREHOLDER thought, as the accounts were not yet passed, that the election of the auditor should be left until they were passed. It would be very premature on the part of the shareholders, after objecting to the accounts, to re-elect the gentleman who audited them. He could not help feeling that if the directors were to blame the auditor was also.

The CHAIRMAN did not know that Mr Dever had done differently to what had been done in other companies.

Mr. DEVER said that he should be very unwilling to press his re-election on the shareholders, but it was right of him to say that the accounts were not objected to at the last meeting. He thought the shareholders objected to the management, with which he had had nothing to do. It was owing to the accounts being fairly stated, and the expenditure and assets fairly displayed to them, that an opportunity had been given to them to exercise their judgment as to the management of the Company, with which he repeated he had nothing to do.

The CHAIRMAN said he perfectly agreed with Mr. Dever, that he simply had to look through the accounts. The directors were quite willing to bear all the responsibility as to the correctness of the accounts. He would be glad if they would look into them, so that they might see that the charge which had been brought against the directors of frittering away the money could not be substantiated. He put the motion in the usual way, and declared it carried, with three dissentients; and the remuneration of the auditor was fixed the same as last year—30 guineas.

The CHAIRMAN then asked if the shareholders had any question to put to the Board, and added that, in the meantime, he might show them the gold medal which he had received on behalf of the Company when it was called the Electric Light and Power Generator Company. The medal had been received from the Crystal Palace, whither he had gone and received it from the Duke of Teck, as well as a diploma of honour. Theirs was the only company that received a medal for their whole system of lighting.

Mr. SAMUEL asked whether the directors of the Lancashire Company had all paid up the amount of their shares.

The CHAIRMAN replied that had nothing to do with this Company.

Mr. SAMUEL thought it had a great deal to do with the Company, seeing that it was dependent for the receipt of £10,000 owing to it from the Lancashire Company on the calls being paid on that company's shares.

The CHAIRMAN stated that all the directors had paid except Mr. Dadson, who had been elected a director, but had not taken his seat.

Mr. SAMUEL understood that Mr. Dadson had the call of a great number of shares in consideration of his taking up a certain number of shares in the Lancashire Company.

The CHAIRMAN replied that there was a certain option, but that it had lapsed. It was true that there was money owing to them by the Lancashire Company, and they were taking measures to get it paid. They had no doubt that they would get it, but it was not always easy to get in calls within a month or two. In reply to a further question, he said that Mr. Dadson was elected to a seat on the Board of the Lancashire Company, not this Company.

Mr. J. S. CAMPBELL said he was not a director of the Lancashire Company, but he did not think it was right, at their meetings, to express any opinion as to whether or not the Lancashire Board had acted properly or otherwise.

The CHAIRMAN observed that he had joined the Board of the Lancashire Company very much against his will, but he did so only because he thought it would be to the advantage of the parent Company. He had paid his calls in the Lancashire Company, and had sold many of his shares at a severe loss in order to do so. Replying to a shareholder, he added that with respect to the raising of the new capital the directors would naturally have done their best as large shareholders to obtain it. He then intimated that this closed the business of the ordinary meeting, and they would now proceed to the extraordinary meeting. The last extraordinary meeting was adjourned because the general meeting was adjourned, and it was decided that they could not go into this question of the new capital on account of the Board not having had a vote of confidence. The same reason existed now, and [illegible] should propose the raising of [illegible] ers. He thought they would [illegible] regarding the matter. They [illegible] consider the [illegible] of the new capital if they adjourned to that day fortnight. If that was their opinion he would move "That the Board had, in consequence of the resolution showing want of confidence in the directors, resolved to place their resignations in the hands of the shareholders, and that a special general meeting be called on the 18th May, for the purpose of electing a new Board." That would give time for sending out notices, and probably there would be a proposal for the raising of the new capital. He wished to remind them that any one desiring to propose new directors must, to legally do so, give at least seven days' notice before the meeting.

Mr. LEE inquired who the gentlemen were who were to propose the new scheme at the next meeting for the raising of the capital.

The CHAIRMAN: You, if you have a good one. He added that, unless the shareholders had anything to bring forward with respect to the position of the Company, the meeting would be dissolved, and a new meeting would be called for the 18th of May. Meantime they were not without hope that among some of their friends a scheme would be brought before the shareholders which would place the Company in a very fair position.

A SHAREHOLDER inquired, if the meeting were dissolved, when the accounts would be passed.

The CHAIRMAN said that nothing happened if they did not pass the accounts, except that the directors were not satisfied.

The MANAGING DIRECTOR (Mr. Hugh Watt) read a statement with regard to the expenses, in the course of which it was stated that the gross sum spent the previous year was £22,500, while the total of the net expenditure of the year now under review had been £9,000. Adding the £4,000 which ought to have been included in the previous year's expenses, the saving this year, as compared with the previous year, had been equal to about 60 per cent. Out of the £9,000 about half had been on plant. He assured them that one of the directors, Sir Herbert Sandford, had been most painstaking, and audited every account, however small. The expenditure had been considerably reduced, and the production had been materially increased. Replying to other questions, Mr. Watt added that the £4,000 which ought to have been included in the expenses of the previous year represented accounts which had not come in by the 31st March, 1881, and could not, therefore, have been included in the accounts for the previous year. The parliamentary expenses had been in connection with the Electric Lighting Bill, which had been promoted by this and the other companies. The £976 for legal expenses represented the ordinary expenses for the year. A large amount of it was in connection with patents.

The SOLICITOR said that the amount had been practically in connection with the purchase of some patents, and costs for the sale of their patents to other companies. The expense of the promotion of the Lancashire Company had had nothing to do with the £976.

The CHAIRMAN said that they had done all they could to cut down legal expenses, and never employed solicitors except where it was essential for the interest of the Company that they should do so. They were obliged to tack improvements on to their own patents, which came from America.

The MANAGING DIRECTOR stated that the legal expenses from the 10th of November, when he was appointed executive officer, had been £100.

The CHAIRMAN pointed out that every information with respect to the accounts could be obtained at the offices. They had nothing to conceal.

MR. MANDER ALLENDER, as a member of the late committee, observed that, provided the necessary changes were made in the management of the Company, the shareholders ought, and it would be to their interest, to subscribe the new capital. But, on the other hand, unless certain changes were made he should subscribe nothing, and should do everything he could to prevent any one throwing more money away.

The MANAGING DIRECTOR said that this remark was made at him, and, therefore, he desired to say that a letter had been received ——

The CHAIRMAN (interposing), remarked that the matter Mr. Watt was about to refer to was private, and that it was better that it should not be gone into. It appeared that the legal expenses referred to had been for two years.

Mr. LANDON (the late secretary) said that the legal expenses were from the 3rd June, 1881, to the 31st December, 1882—that was to say, for a year and a half exactly.

Mr. INVERARITY thought that there could be no objection to pass a reso-

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lution increasing the capital to £500,000, leaving the details to be settled at the next meeting. The resolution, if passed, would be for the next meeting to confirm.

The CHAIRMAN considered it would be better to leave the question of raising fresh capital for the next meeting.

A SHAREHOLDER, however, pointed out that the next meeting could refuse to confirm the resolution.

Mr. INVERARITY, at the request of the meeting, then stated that his scheme for raising the new capital appeared to him to be quite feasible, but it was based on the shareholders assisting. His plan was this—that the capital of the Company be increased nominally to £500,000 by the creation of 327,000 new shares of £1 each; that the directors be authorised to issue at once £50,000 of these new shares to the existing shareholders at the price of 6s. 8d. for the £1 share, such price to be paid half on allotment and half not less than three months subsequently. The price of the shares that day was not 6s. 8d. and consequently a shareholder taking up any number of shares at 6s. 8d. had a right to some compensation. He therefore proposed that each shareholder taking up any portion of the 50,000 shares should have the call for a period of 18 months of an additional allotment of two shares of £1 each for every share taken at the same price of 6s. 8d. Therefore, any one taking up one share now at 6s. 8d. would have the call by his plan of two other shares at the same price, so he would practically get three shares for the price of one. He should propose, however, that no general allotment on these terms should take place unless three-fourths of the whole £50,000 were subscribed for. Suppose a shareholder took 50 shares it would cost him £16 13s. 4d. He would pay half of that on allotment and the second £8 6s. 8d. three months afterwards. Hence, for £16 13s. 4d., he would get fifty shares with the option of calling up within eighteen months 100 shares at the same price. As a matter of fact, if every shareholder took thirty-five shares at 6s. 8d., it would place the Company in a most flourishing position.

The CHAIRMAN stated that it was well that the shareholders should have heard this statement. He desired to assure them of his belief that not only in the public mind, but in the minds of most of the other large electrical companies, this Company possessed the best patents extant: and from the continued applications to them for concessions for electric lighting plant and for installations, he was satisfied that it was growing rapidly in the public mind. He concluded by asking them whether it was their pleasure that the resolution increasing the capital should be passed that day, leaving its confirmation for the next meeting.

Mr. INVERARITY pointed out that that would only authorise the creation of the capital that day.

After some further discussion the printed resolutions in the notice calling the meeting were passed as follows:—

"That the nominal capital of the Company be increased by the addition thereto of 327,500 shares of £1 each beyond the registered capital of £172,500, in 172,500 shares of £1 each, making the total capital £500,000.

"That such 327,500 shares may be allotted at the discretion of the directors, on such terms and at such times as they think fit, and either at a premium or at a discount."

A vote of thanks to the chairman and directors brought the proceedings to a close.

ELECTRIC LIGHTING FOR LEEDS.

Last week we gave a brief note stating that the Leeds Corporation had resolved to adopt the electric light for the Town Hall and certain streets. We now give a *résumé* of the proceedings of the meeting at which the above resolution was adopted, taken from a Leeds paper:—"Alderman Tatham proposed—That the council proceed with the application for, and include in, the draft provisional order for electric lighting the following as the areas to be included in Schedules A and B:—namely, Schedule A—So much of the borough of Leeds as is contained within the following boundaries, namely:—From Great George-street along Oxford-place to Park-lane, thence along Park-lane to East-parade and along East-parade, thence along Bond-street to Park-row, thence along Park-row to Park-lane, thence along Park-lane to Calverley-street, thence along Calverley-street to Great George-street, and thence along Great George-street to the commencement of the boundary in Great George-street. The streets within the aforesaid area along which the undertakers are to lay distributing mains, and the places proposed to be lighted by the undertakers within two years from the commencement of the order are the following:—In Victoria-square, in front of the Town Hall; in Calverley-street, in front of the municipal buildings; within the Town Hall, in Victoria-square; and within the new municipal buildings and the new free public library, forming part thereof. Schedule B—The whole of the municipal borough of Leeds, as the same is constituted under the provisions of the Acts relating to Municipal Corporations, and of the local Acts relating to the borough at the date of the commencement of the order, excepting the area included in Schedule A. Continuing, Mr. Tatham said that the Electric Lighting Act was a very intricate measure, prepared with the idea that not only was the electric light to be the light of the future, but that there would be a quick demand for that light. These views had not yet been realised, although they might be in the future. No company had yet been able to take up the work of lighting large towns with success. The Electric Lighting Committee, in the first instance, did not think it advisable to adopt the compulsory powers of the Act, because they feared they might be called upon to carry out something that would be neither profitable nor beneficial. There was some difference of opinion, however, as to the liability they might have to undertake, and legal opinion was obtained. The committee were given to understand that they were not bound to carry out the lighting of any area if it were found to be unprofitable to do so; but that if they did not do so they would forfeit the powers allowed under the provisional order giving them the exclusive privilege of lighting the town. Although some members of the committee thought it would be better to do without an order altogether, and simply be content with lighting the corporate buildings, others were of opinion that it would be well to take a fair area, and supply that area under the terms of the provisional order. After a long discussion in committee, the prevailing sentiment was that they might safely recommend the council to adopt the area suggested in the resolution he had proposed. The provisional order first of all would give power to light the whole of the borough, but it also required that they should define a particular area, to be called area A, in which the council would be bound to supply electricity within two years. When that was done, those living in other parts of the area might, at the expiration of that period, claim to be supplied with the electric light. From time to time the corporation could add portions of area A to area B under the same conditions of supply, and if persons living within 250 yards of area A thought they were not properly supplied, they could apply for an order to compel the corporation to supply them with the light. The committee were of opinion that if they acquired the powers now recommended, they would be able to protect themselves against injury in respect of future competition."

COMPANIES' SHARE LIST.

TELEGRAPHS.

COMPANIES.	CLOSING PRICES MAY 9.		BUSINESS DONE WEEK ENDING MAY 9. Highest.	Lowest.
Anglo American	51,	52	51⅞	51⅛
Do. Preferred	83½,	84½	84½	83¾
Do. Deferred	20⅞,	21⅛	21⅛	21
Brazil Submarine	12½,	12¾	12¾	12⅛
Cuba	10,	10⅛	10⅛	10⅛
Do. Preference	17,	18	17⅛	17⅛
Direct Spanish	5⅛,	6	5⅞	5⅛
Do. Preference	16⅛,	16¾	—	—
Direct United States Cable	12⅞,	13	12 15-16	12 11-16
Eastern Telegraph	10⅞,	11	11	10⅞
Do. 6 per Cent. Preference	13⅛,	13¾	13 9-16	13 7-16
Do. 5 per Cent. Debentures, 1899	10⅛,	107	106⅞	106⅞
Eastern Extension	12,	12⅛	12⅛	12 1-16
German Union	10,	10⅛	10⅜	10⅛
Globe Telegraph and Trust Company	7,	7⅛	7 5-16	7⅛
Do. Preference	12⅞,	13⅛	13⅛	12 15-16
Great Northern	12⅞,	13	13⅛	12⅞
Indo-European	33,	34	—	—
Mediterranean Extension	1⅛,	2	—	—
Do. Preference	6,	7	—	—
Reuter's	9⅛,	10	—	—
Submarine	247,	252	250	249
West India and Panama	1⅛,	1⅛	1⅜	1 5-16
Do. 1st Preference	7⅛,	8	7⅛	7⅛
Western Brazilian	7,	7⅛	7⅛	7
West. Union 7 per Cent. 1st Mortgage	122,	124	—	—
Do. 6 per Cent. Sterling Bonds	103,	106	—	—

TELEPHONES.

Consol. Telephone and Maintenance	⅝,	¾	¾	11-16
Oriental	¼,	⅜	⅜	⅜
United Telephone	9⅞,	10⅛	10⅛	9⅞

ELECTRIC LIGHT.

Anglo-American Brush Lgt. (fully pd.)	3½,	4	4⅛	3⅞
Do. (fully paid)	5½,	6½	7	6
Hammond Light	2,	2½	2⅞	2⅛
Pilsen, Joel, and General Electric	⅛,	⅜	—	—
Swan	1⅛,	1⅛	1 13-16	1 9-16
Maxim-Weston	⅛,	⅜	⅜	3-16

TRAFFIC RECEIPTS FOR APRIL, 1883.

COMPANIES.	April, 1883.	April, 1882.	Increase.	Decrs.
Anglo-American Telegraph Company	—	—	—	—
Brazilian Submarine Company	—	—	—	—
Cuba Submarine Company	3,900	3,921	—	21
Direct Spanish Telegraph Company	1,766	1,824	—	58
Direct United States Cable Company	—	—	—	—
Eastern Telegraph Company	45,148	42,667	2,481	—
Eastern Extension Telegraph Company	32,005	29,269	2,736	—
Great Northern Telegraph Company	20,400	—	—	—
Submarine Telegraph Company	—	—	—	—
West Coast of America Telegraph Company	—	—	—	—
Western and Brazilian Telegraph Company	—	—	—	—

NUMBERS OF "THE ELECTRICIAN" OUT OF PRINT.—The following numbers of *The Electrician* are out of print, and cannot be supplied at the office, viz.:—Vol. 1, Nos. 3, 9, 19; Vol. 7, Nos. 8, 10, 12 to 18, 20, 21, 24 to 26; Vol. 8, 1 3, 6 to 12, 15 to 26; Vol. 9, Nos. 2, 4, 24, 25; Vol. 10, No. 13.

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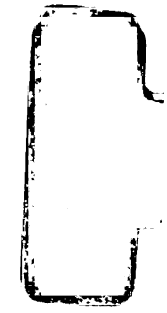

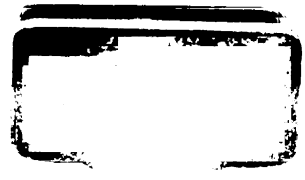

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